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Editorial Comments

The Charting of Wave Motion.

The translation of the article on Wave Action in relation to Harbour Protection Works, written by a distinguished Spanish engineer, Señor R. Iribarren Cavanilles, which we reproduce this month from the *Revista de Obras Publicas,* directs attention to one of the most difficult, as it is also one of the most fundamental, problems of harbour breakwater design, viz.: the determination of wave force and its effect on maritime structures. Señor Cavanilles points out the danger involved in proceeding along lines dependent entirely on intuition and assumption, and proceeds to describe a method of determining from data, either experimentally known, or based on reasonable deduction, the characteristics of waves approaching a shore line, and therefrom the construction of charts of wave motion which enable the action to be visualised and locally defined.

The subject of wave action on harbour works has on several previous occasions been dealt with in our columns, and readers will recall the informative articles on International Studies on Wave Force in the issues of May and June, 1939, in which Dr. Herbert Chatley reviewed the publication in *Annales des Ponts Chaussés,* 1938, of the result of the studies of MM. de Rouville, Besson and Pétry, and of MM. Beau and Beaudelaire. While these studies, however, confined themselves to the specific determination of maximum forces, Señor Cavanilles' exposition is directed towards showing the gradual shoreward development of wave action in coastal waters and he exemplifies his calculations with the aid of charts relating to storm waves arising from three points of the compass at the harbour of Palma, in the island of Mallorca, or Majorca, the largest of the Balearic group which lie in the Mediterranean off the Eastern Coast of Spain.

If anything in the nature of criticism is called for in regard to this carefully thought out and detailed exposition, it is that it seems to err, in our opinion, on the side of over elaboration in the face of conditions which, from the nature of things, do not admit of much exactitude. The three limiting boundary lines of alimentation, expansion and agitation, cannot be regarded as otherwise than speculative, though the attempt to define them is commendable enough and may have a certain general value. It is only fair to admit that Señor Cavanilles has a more intimate acquaintance with the conditions prevailing in Palma Harbour than can be gained from a superficial inspection of the charts, and full credit must be given to him for the service he has rendered in setting out the results of his experience in the locality.

At the same time, it should be pointed out that sea conditions in the Mediterranean are of a special character and in one respect at least of limited applicability elsewhere. The Mediterranean is what is known as a "tideless" sea, and its surface level varies within a relatively narrow range. It is, therefore, no difficult matter to arrange the line of a breakwater so that it may lie within depths which will ensure that storm waves shall invariably be reflected before breaking, whereas in the Atlantic and other seas and oceans, such an ideal may be unattainable.

There exists, or at any rate before the present war there did exist, an International Committee promoted by the Association of Navigation Congresses for the study of wave force and much useful information has been gained from the investigations and reports of MM. Bénézit, Sainflou, Lira, Coen Cagli and Larras among other foreign engineers. In this country, the Institution of Civil Engineers' Research Committee set up in 1935 a Committee on Wave Pressures, which initiated a series of model experiments in tanks on which an interim report was made by Major R. A. Bagnold in 1939 (*vide Journal of the Institution of Civil Engineers,* June, 1939, p. 202). This important research has necessarily been in abeyance since the outbreak of war, but will probably be resumed as soon as peace conditions are re-established.

Every harbour engineer will agree in the desirability and even urgency, of a full and scientific determination of the problem of wave force on breakwaters and other harbour structures. Señor Cavanilles' contribution to the study of the matter is therefore very welcome and will be studied with interest.

Depreciation of Port Plant.

The depreciation and obsolencence of plant and machinery are matters requiring the careful consideration of all users of mechanical appliances, and they are of special importance to port authorities as affecting the book values and " lives " of numerous quayside installations. In an article published in this issue, an accountant explains two methods by which the question may be treated, and his exposition will, we hope, be of service to those who have to deal with such matters, especially as regards valuations for statements of assets, rating assessments, and the like.

In a recent discussion on the subject at a meeting of the American Society of Engineers, it was pointed out by one of the speakers (Mr. Jas. T. Ryan) that there are actually three aspects of the term Depreciation to be considered and, despite the tendency to mingle, if not to confuse, them, they should be carefully differentiated.

Editorial Comments—continued

First, there is the Economic concept of the word in which Depreciation (properly so called) relates to decline in monetary value.

Secondly, there is the engineering concept in which the sole consideration is impairment of utility and loss of efficiency. In our view the proper term for this would be Deterioration.

Lastly, there is the Accounting concept which concerns itself entirely with the extent to which original capital is lost or consumed in current operations. This is, of course, not the same thing as the Economic concept: it is based on cost, not value; in other words, it is the amortization of the plant. The article in this issue is naturally written from this point of view.

The accountancy side of port undertaking is of no less importance than the administrative and operating sides, and an accurate appreciation of the principles underlying sound book-keeping is essential to effective management. Accordingly, we feel that an article on the subject should be of interest.

The Merseyside Allegations.

In our last issue, we published certain correspondence, which had appeared in the daily press during the month of August, containing detailed charges of slackness and lack of discipline on the part of dock workers at the Port of Liverpool, and in commenting thereon, we expressed the hope that a competent and independent investigation into the circumstances of the case, such as was suggested in a leader in *The Times*, would be undertaken.

Since then, the Government, through Lord Snell in the House of Lords, have announced that Sir John Forster, a member of the National Arbitration Tribunal and chairman of the Railway Staff National Tribunal, had been appointed " to review and report on the conditions pertaining in the Merseyside Docks."

Lord Winster, speaking after the announcement, said he supposed that the enquiry would cover the allegations which had been made.

From a subsequent statement in the press, it would appear that the enquiry is to be held in private and that it will be opened on September 30th and be continued from day to day until all the evidence has been taken. Sir John, who has made a preliminary visit to Liverpool, including an inspection of the docks, in order to gain personal impressions of the work going on and the conditions under which the activities of the port are proceeding, has intimated that it is his intention to make the enquiry exhaustive and has expressed his willingness to take the evidence of any interested party " who could submit memoranda that would be helpful and applicable."

We have also learned that the findings at the enquiry may not be available for publication. If this is so, we think it is a matter for regret, since the accusations having been made openly, it is clearly desirable that the relevant facts should be disclosed in order that any exaggerations or inaccuracies may be dismissed from the public mind—for the public are undoubtedly concerned about the matter—and, on the other hand, that any irregularities actually found to exist may be suppressed and eradicated.

Such is the position of affairs at the moment of going to press, several days in advance of the opening of the enquiry. If there are any developments, reference to them must necessarily stand over till the next issue.

The Shipping Situation.

Shipping and shipbuilding are subjects, which, generally speaking, lie outside the sphere of this Journal, except in so far as it is necessary to touch upon them in regard to their operations within port areas for the purpose of receiving and discharging cargo and as governing the conditions of port development and expansion. At the same time, ports and shipping are so intimately associated in regard to their functions and object that no port official can be indifferent to the welfare of shipping, especially that which visits his own port. Ports are fed by shipping and when shipping declines, or fails, the port suffers in company.

The gloomy shipping outlook at the present time is therefore a serious concern of port authorities and the recent crisis during which the very existence of overseas traffic has been menaced by the intensity of the U boat campaign, cannot but have overshadowed all discussions and decisions in port administration in this country.

It has therefore been a great relief, after a prolonged period of anxiety and depressing returns, to have the authoritative assurance of the Prime Minister in his recent review in Parliament of the war situation, that during the months of July and August and in the early days of September, there has been a marked rate reduction in the number of ships lost. The official announcement is made that the line of new building of merchant ships of the United Nations has now definitely crossed and maintained itself in the graphs above the line of sinkings. This good news will put fresh heart into the gallant merchant navy which has struggled so courageously in the face of adverse circumstances, as it will also be an encouragement to port workers, who have toiled unremittingly to make the best use of the limited tonnage available.

On the co-related point of U-boat sinkings, the Prime Minister was not able to speak so confidently. He was unable to say that the sinkings of the U-boats have nearly kept pace with new construction. " On the other hand," he added, " our heavy and successful bombing of the German shipbuilding yards will have an increasing effect upon the output and assembly of U-boats, while the part which the air is taking in the U-boat warfare grows in importance with every week that is passed."

Subversive Agencies in Port Labour Troubles.

At the recent enquiry at the Port of Grimsby into the cause of stoppages of work at that port and at Immingham, it was stated that there were difficulties in inducing quotas of men from London, Bristol and the Channel ports to work on the East Coast and that there was organised obstruction to the operation of the mobile port labour scheme. Agitators in imported squads were accused of fomenting strikes among local workers.

Sir Charles Doughty, K.C., who conducted the enquiry, said he was satisfied that the people really responsible for the stoppage were not represented at the proceedings, one of the objects of which was to prevent a small and irresponsible minority of men upsetting a " large majority of decent fellows who did not want to have it thrown at them for the rest of their lives, that they came out on strike in war time." Sir Charles is to report on the matter to the Minister of War Transport.

The P.L.A. Mace.

An interesting history attaches to the mace which, in a manner similar to that in vogue at many civic council meetings, is placed is position at sessions of the Port of London Authority. The story as related in a recent issue of the *P.L.A. Monthly*, is as follows:

In 1925 Lord Knutsford presented to the Authority a mace which was given to the old West India Dock Company in 1803 by Mr. George Hibbert, M.P., the then Chairman of the Company, who was Lord Knutsford's great-grandfather.

Throughout the existence of that Company the mace was placed immediately behind the Chairman whenever the Court of Directors was in session, and the practice was continued by their successors in the ownership of the Docks until 1909, when the dock companies were dissolved consequent upon the constitution of the Port Authority. The mace then passed into the possession of Lord Knutsford, who deemed it fitting that it should adorn the Board Room of the Authority. Lord Ritchie, then Chairman, instituted the practice of using the mace as it had been used by the Authority's predecessors, and at each meeting of the Board from 1925 onwards the mace has been placed in the clips at the back of the Chairman's seat.

Alderman Hibbert, M.P., was a West India Merchant and Shipowner, and had interests in West Indian sugar plantations. He was also a collector and connoisseur. The staff of the mace is a splendid specimen of a sugar cane. The ship which surmounts the top of the globe is a West Indiaman named Hibbert, obviously named after the owner, depicting her with topmasts housed and yards aback as prescribed by the old dock regulations for ships moored at the quays of the West India Docks. The mace therefore provides an interesting link between the West India Company consisting of West India merchants, shipowners and planters, and the West India Dock Company.

*Wave Action in Relation to Harbour Protection Works**

With Special Reference to the Port of Palma, Mallorca

By RAMON IRIBARREN CAVANILLES.

Charts of Wave Propagation

THE lay-out of protective works for a harbour constitutes one of the most delicate problems which can be undertaken by the engineer-designer of maritime works.

If he does not proceed on simple intuition in his determination of the form and arrangement in plan of the projected works of protection, he accepts, in general, as the closest possible theoretical approximation, a crude and absolute delimitation of the zone to be sheltered, by straight lines, as arbitrary in their outline as in their direction.

In the determination of these arbitrary lines for the limits of the sheltered area, there is neglect to take into account phenomena of importance, such as the propagation or lateral expansion of the wave, broken in its advance by the obstacle which the work constitutes, or by any coastal salient, and the gradual diversion of the line of advance of the wave, and as a consequence the variations in its shape due to its propagation in different and variable depths.

Experiments with models on a reduced scale form a most desirable procedure, but it is not always possible to make use of the means necessary to perform them with due and scrupulous precision, by reason of scalar reduction, and it must not be overlooked that the difficulty of determination and the proper application of scales in these great reductions, and the whole of the circumstances, in which the phenomena are reproduced, render delicate the application to a natural scale of the results obtained from the model.

All this goes to show the great advantage of arriving at a development of a practical method which permits of the solution (if even with no more than with a certain appropriation) of the problems propounded.

We are of opinion that, once properly explained, the method about to be described, which may be termed the charting of wave motion, affords a sufficient approximation for the majority of practical purposes.

This method consists simply in determining the form of propagation of a wave of known characteristics and direction in the open sea, in advancing towards a determined coast-line, the depths and bathymetric contours of which are known, together with the form and orientation of the natural seaboard, as also the protective works executed and those which can be supposed constructed.

For this purpose, the trochoidal theory, now generally accepted, can be adopted as a basis, since, properly applied, it explains the observed phenomena satisfactorily.

Recalling this theory, it is accepted that the orbits of the liquid molecules, set in motion by the wave, are circular, provided that they are propagated in water of indefinite depth. Although, theoretically, it is necessary that this depth H should be infinite, in order that it may be considered indefinite; practically it suffices if it is equal to, or greater than, the semi-length of the wave, so that the conditions of propagation can be considered analogous to those of a wave of like characteristics propagated in greater depths.

The simple observation of the curves in Fig. 1, in relation with their asymptoles, justifies this practical approximation, which can be expressed by saying that the wave, which is propagated in decreasing depths, succeeds practically in touching the bottom, and commences in consequence to become deformed and to modify its conditions of propagation when the depth H of the sea is equal to, or less than, the semi-length of the original wave L_o.

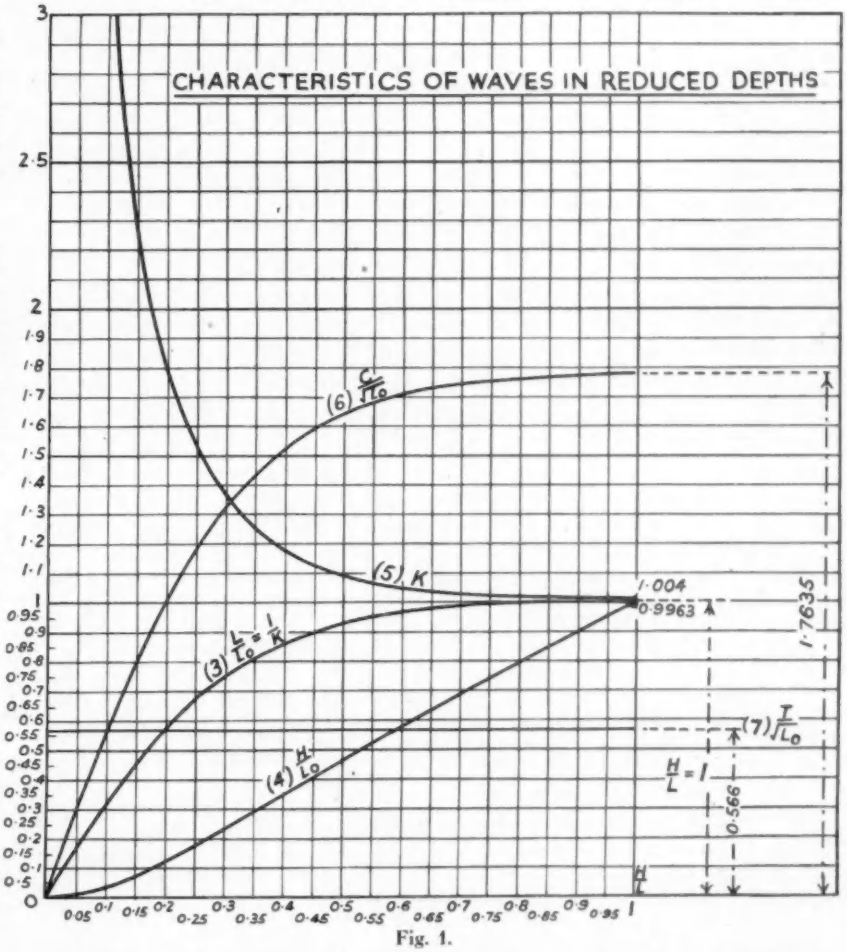


Fig. 1.

In what follows, it will be assumed that by means of direct observation, there is known the height, $2h_o$, and the length, $2L_o$, of the greatest possible wave on the open sea or in deep water, for which $H \geq L_o$, and also that there is a definite direction in which the wave encounters the coastal platform on which the work is designed to be constructed.

*Translated from the Spanish article, "Obras de Abrigo de los Puertos," in *Revista de Obras Publicas*, January, 1941.

Wave Action in Relation to Harbour Protection Works—continued

If this is not the case, it is still possible to determine, approximately, the maximum possible characteristics of this wave by means of the expressions: $2h_0 = 1.2\sqrt[4]{F}$ and $2L_0 = 3.5\ (2h_0)^2$, in which F is the line of water surface or distance corresponding to the direction in question, measured in kilometres, and the height and length of the maximum possible wave are given in metres.

The justification and possibly the relation of these expressions, probably quite sufficiently approximate, although logically, they require a certain margin of safety, will be the object of another study which will be published when it is possible to compile more complete data, really worthy of credence, and free from the exaggerations so frequent in such matters, arising from the imposing aspect of the phenomenon presented to the astonished mariner exposed to its action, or due to the subconscious exaggeration of the engineer called upon to account for damage to his work.

There are known then, even if only approximately, the characteristics of the greatest possible wave which can be propagated in deep water, $H \geqq L_0$, or say, its height $2h_0$, its length, $2L_0$, its velocity $C_0 = \sqrt{\frac{g}{\pi}\frac{L_0}{K_0}}$, its period $2T_0 = 2\sqrt{\frac{\pi}{g}L_0 K_0}$, and the relation of the orbitary superficial semi-axes $K_0 = \cot h \frac{\pi H}{L_0}$ which from its close approximation in these great depths to unity, enables us to assume that if $H \geqq L_0$, the orbits are practically circular, and it is permissible to simplify the foregoing expressions, making $K_0 = 1$.

We can now determine the characteristics of the wave $2h$, $2L$, C, $2T$ and K, when it is propagated in its advance over the coastal platform, in a depth H, known and less than L_0, for which we begin by indicating that $T = T_0$, or, say, $\sqrt{\frac{\pi}{g}LK} = \sqrt{\frac{\pi}{g}L_0}$, which is equivalent to stating that, once the storm is in being, it propagates, as is logical, the same number of waves during a stated period at the extremity of the coastal platform as at any point of the same; from which we obtain the equation $LK = L_0$, which, taking $K = \cot h \frac{\pi H}{L}$, permits us to deduce the values of L and K, since L_0 and H are known.

The equation of the trochoidal theory, $C = \sqrt{\frac{g}{\pi}\frac{L}{K}}$, also permits us to determine the velocity corresponding to this reduced depth H.

The following table can easily be calculated in which are laid down the characteristics L, H, K, C and T, corresponding to reduced depths $H \leqq L_0$ as a function of the relation $\frac{H}{L}$ and of the original semi-length L_0.

Characteristics of waves in reduced depths:—

(1)	(2)	(3)	(4) = (1) × (3)	(5) = $\frac{1}{(3)}$	(6) = (3) $\sqrt{\frac{g}{\pi}}$	(7) = $\sqrt{\frac{\pi}{g}}$
$\frac{H}{L}$	$\frac{\pi H}{L}$	$\frac{L}{L_0} = \frac{1}{K} = \text{tgh}\frac{\pi H}{L}$	$\frac{H}{L_0} = \frac{H}{L}\cdot\frac{L}{L_0}$	$K = \text{cotgh}\frac{\pi H}{L}$	$\frac{C}{\sqrt{L_0}} = \frac{\sqrt{\frac{g}{\pi}}}{K}$	$\frac{T}{\sqrt{l_0}} = \sqrt{\frac{\pi}{g}}$
1	3,14	0,996	0,996	1,004	1,764	0,566
0,95	2,98	0,995	0,945	1,005	1,761	
0,90	2,83	0,993	0,894	1,007	1,758	
0,85	2,67	0,989	0,841	1,011	1,750	
0,80	2,51	0,987	0,789	1,013	1,747	
0,75	2,36	0,982	0,737	1,018	1,738	
0,70	2,20	0,976	0,683	1,023	1,727	
0,65	2,04	0,967	0,632	1,034	1,711	
0,60	1,88	0,955	0,573	1,047	1,690	
0,55	1,73	0,939	0,517	1,065	1,662	
0,50	1,57	0,917	0,459	1,091	1,623	
0,45	1,41	0,888	0,399	1,126	1,571	
0,40	1,26	0,851	0,340	1,175	1,506	
0,35	1,10	0,801	0,280	1,250	1,417	
0,30	0,94	0,735	0,221	1,361	1,301	
0,25	0,79	0,658	0,165	1,520	1,165	
0,20	0,63	0,558	0,112	1,792	0,989	
0,15	0,47	0,438	0,066	2,283	0,776	
0,10	0,31	0,300	0,030	3,333	0,532	
0,05	0,16	0,159	0,008	6,289	0,281	
0,04	0,126	0,125	0,005	8,000	0,222	
0,03	0,094	0,094	0,003	10,661	0,166	
0,02	0,063	0,063	0,001	15,898	0,111	
0,01	0,031	0,031	0,000	32,258	0,055	
0,00	0,000	0,000	0,000	∞	0,000	
Adjustments		$L_0 = LK$			$C = \sqrt{\frac{g}{\pi}\frac{L}{K}} = \sqrt{\frac{g}{\pi}\frac{L_0}{K^2}}$	$T = \sqrt{\frac{\pi}{g}LK} = \sqrt{\frac{\pi}{g}L_0}$

From this table, taking as abscissæ the values of $\frac{H}{L}$ and, as ordinates, the corresponding values in each column, the curves corresponding to each characteristic sketched in fig. 1, can be deduced and their practical application could not be simpler.

Knowing the original semi-length L_0 and the depth H, corresponding to the selected point in the coastal platform, we know the relation $\frac{H}{L_0}$, which we insert in the axis of the ordinates and determine the corresponding point of the curve (4). The ordinate which passes through this point fixes in each curve and in terms of L_0, the remaining characteristics of the wave, corresponding to the reduced depth of propagation, H.

It is not necessary to complete the range of orbitary elliptical movement and other aspects of the phenomenon assumed in the trochoidal theory in reference to reduced depths—they are

Wave Action in Relation to Harbour Protection Works—continued

merely guesses when the depth is variable; indeed, the results obtained by means of first approximations, assuming the judicious application of the theory, are more acceptable for practical purposes, provided that they are deduced and interpreted properly.

With respect to the Utopian exactitude of the results obtained in the majority of engineering problems it must be obvious that, except in land works, in which an allowance generalises the degree of credibility of everything that is obtainable, the approximation obtained is not often superior to that which can be attained by the rational application of methods which we recommend for maritime works.

adapt itself instantaneously and at every point to the depth to which it is strictly in correspondence, but moulds itself to the mean depth of a zone of a certain expansion, which includes the point in question.

What amplitude corresponds practically and with sufficient approximation to this zone? How does it appear to get rid logically of the earlier liability, in particular, in regard to the depth L, which practically controls the orbital movement, as also the terms of the formulæ obtained by means of the application of the trochoidal theory and of the equation of the trochoid itself, in which it can also be considered that its semi-unity of lengths is precisely that semi-length of the wave L, and as, more-

The Harbour and Port of Palma, Mallorca.

The defenders of the simple, indeed only too frequently catastrophic, procedure which may be designated intuitive, or by illusory comparison, generally employed in the preparation of plans for maritime works, obstinately resist the application of other methods whatsoever, alleging the defect of inferior approximation. If this were so, is it right that in land works in which with excessive frequency, we repeat, it is assumed everything is known, we employ large factors of safety and claim, in exchange, to apply the proposed methods to maritime works in which, perhaps too conveniently, it is assumed that nothing is known, without adopting any margin of safety?

Frankly, we consider that with co-efficients of safety less than those employed in numerous land works, it is possible to have confidence in the results obtained by the methods which we propose for maritime works and which we hope to complete to better effect by means of later research and closer observations.

A feature which it is desirable to clear up is that of the depth H, which has to be applied in the formulas and in curves, in order to determine the approximate characteristics of waves propagated in variable depths.

It is indubitable that in the admirably ordered orbitary motion of the liquid molecules, actuated by the progress of the wave, there cannot be produced, otherwise than in extreme cases, abrupt discontinuities in its smooth gradations, which in accordance with the law of least effort, tend to diminish the displacement of some molecules with respect to those which are adjacent.

This resolves itself, practically, into a certain rigidity of form in the wave, which means that if there are discontinuities in the slope, or surface, of the bottom, the advancing wave does not over, it appears to be confirmed by various experimental results, such as those of Harris, which make it reasonable to accept as a first substantial approximation that the length which affects practically and in both directions, as much in the line of propagation as in that transverse to it, the characteristics of the wave corresponding to a certain point, is the previously mentioned semi-length of the wave L?

It appears logical, and observation tends to confirm it, that the speed and the remaining characteristics of the asymmetrical wave with respect to the vertical which passes through the crest depend more on the anterior, than on the subsequent, semi-length. This asymmetry of the deformed wave in greatly reduced depths is interesting under other aspects, but scarcely has practical bearing on the present investigation other than in some extreme case.

We have established matters so that it is possible to define the quadrilateral of advance of the point in question which we shall examine forthwith.

Although, if, as appears somewhat improbable, that assumption was not sufficiently practical, it will suffice with the results obtained, that they should be (as is logical) sensibly proportional to actuality, so that they may be acceptable for the proposed end.

Furthermore, in the general case, in which the slope of the bottom over which the wave travels is practically uniform, all this loses interest; then it suffices to take as depth H, that corresponding to the point under consideration and it is only necessary to determine the mean depth of the quadrilateral of advance when there are within it discontinuities of some importance, as can occur on rocky coasts and in the vicinity of artificial works.

Wave Action in Relation to Harbour Protection Works—continued

With all this explained, we have the data necessary to determine the form of advance over the coastal platform of a storm of known direction and length of wave in the open sea.

Let the straight line *MN* (fig. 2) be the crest of the wave which advances in a direction normal thereto, towards the coast line and which always propagates itself in depths greater than its semi-length L_0, previously ascertained.

At the end of the semi-period T_0, each point, 1, 2, 3, 4, 5,, etc., distant from one another an arbitrary distance A_0, which can very well be equal to L_0, will have passed to the positions $1_2, 2_2, 3_2, 4_2, 5_2$, and will constitute a line parallel to the previous line, since all have advanced a semi-length of the wave $L=L_0$ in a direction normal to *AB*. For scalar convenience, a multiple of L_0 may be taken, although the approximation obtained later may be less.

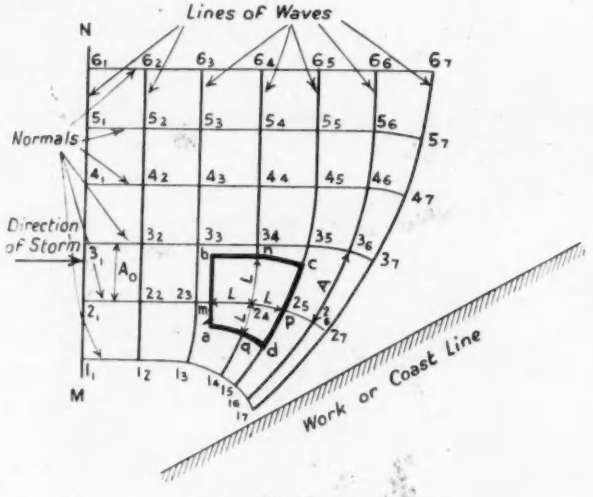


Fig. 2.

Matters continue thus in successive equal and rectilinear advances until a part of the wave, as shown in the lower part of the figure, encounters in its advance depths less than L_0.

To each point of this zone, or in cases of discontinuous bottoms in its quadrilateral of advance, there will correspond a depth H, less than L_0. Having determined this depth H, we know the relation $\frac{H}{L_0}$, which we introduce into the axis of ordinates of fig. 1 and we determine the corresponding point of the curve (4), the ordinate of which fixes for us, in the remaining curves, the characteristics of the wave which propagates itself in the depth H and we obtain, thus, in curve (3) the relation $\frac{L}{L_0}$, or, say, the value of L, or of the advance sought, corresponding to the semi-period, or its multiple, and the point considered.

In some special cases, where we wish to refine to a greater degree, we can take as value of L, or of its multiple fixed for scalar convenience, the mean of the values corresponding to the origin and termination of the advance sought, from which we can proceed by measurement in a similar way to that indicated directly by the quadrilateral of advance.

In place of the curves in fig. 1, there can also be utilised, perhaps more conveniently, the table from which they have been compiled, providing, in each particular instance, two additional columns: 1, of depths H, or, say, the values in column (4) multiplied by the corresponding L_0, and the other of the respective advances, or, say, those of column (3), multiplied by the length represented by L_0, or by its adopted multiple, to the scale of the chart.

In order to determine, in case of necessity and with sufficient approximation, the quadrilateral of advance, for example that corresponding to point 2_4, constituted by two sets of lines of the wave *ab* and *cd* and its normal correspondents, *bc* and *ad*, we must proceed by measurement, assuming the semi-length L of the desired advance, which is that which serves, in the form indicated in fig. 2 for the construction of the said quadrilateral, and ascertaining, as has just been explained, if it really coincides or is a sufficient approximation to the assumption. With a little practice, the first measurement suffices to attain sufficient approximation; then, to quote the words of our renowned professor, D. Eugenio Ribera, referring with his great practical wisdom, to the majority of engineering problems: "It is no good calculating to millimetres, if the premises are in decimetres." In many of the cases which present themselves, it suffices to take as the mean depth of the quadrilateral *a b c d*, the arithmetical mean of the depths corresponding to the points *m*, *n*, *p* and *q*.

So for the measurements indicated previously as for other refined technical calculations, in which it is necessary to perform numerous operations, it will be found that the approximation obtained by the slide-rule is sufficient.

The lines of the wave, or say the successive positions of its crests or troughs, will be the curves resulting from the union of the relative points; for example, $1_4, 2_4, 3_4, 4_4$, etc., and the normals can be constituted by straight lines drawn carefully normal to the line of the preceding wave. Thus the $2_4, 2_5$ will be a straight line normal at 2_4 to the curve $1_4, 2_4, 3_4$, etc.

In the case in which the quadrilateral of advance is intersected by the coastline, or by any work, as at the point *P* in fig. 3, it can be admitted that it is only necessary to take into account for the determination of the mean depth of propagation of the wave, the wetted portion of the said quadrilateral, or say the area *a*, *b*, *n*, *m*, which alone can influence the characteristics of the wave, instead of the whole *a*, *b*, *c*, *d*, since the orbitary movements can only affect the immersed portion in question.

There is scope for a better determination of the mean depth in the case of wave reflection, by taking into account the wetted part of the quadrilateral of advance with the corresponding part of the reflected wave.

With this exposition, we have sufficient to determine with adequate approximation the form of advance in plan of the wave, then we can draw its successive positions which we have called wave lines, also its normals, and the only thing wanting to resolve the problem which has been outlined is the height of the wave at any point.

For this, we know that the energy corresponding to the breadth A_0 (fig. 2) of the original wave in deep water, and included in the length of the wave, is that $E_0 = A_0 \rho g L_0 h_0^2$ in which ρ is the density of the liquid, g is the acceleration due to gravity, and h_0 and L_0 the semi-height and semi-length determined at the beginning of the investigation.

The analogous expression for the energy, $E = A \rho g L h^2$ can be used in reduced depths, provided that the wave is remote from its breaking point.

If the energy E_0 is conserved in the forward movement of the wave, the contractions of L_0, which are reduced to the L corresponding to the point considered, will involve an increase in h_0, which will transform it into the corresponding h.

Although in every case we do not possess the whole of the data necessary for precision, we can agree that consumption of energy caused by the advance of the wave, compensates approximately for the increase in semi-height, h, produced by the contraction in semi-length L on the slopes frequent in coastal platforms and approximating to 1 in 100, provided that the wave is not near breaking point.

Although steeper slopes can increase somewhat these heights and flatter slopes can sensibly diminish them, and in a form which will be definable when it may be possible to compile the requisite data, much greater importance, in relation to the variation of height of propagation of the wave, attaches to its expansion in a direction transverse to its advance and that can be determined by the divergence of the normal lines already laid down. This expansion we will call "frontal" to distinguish it from lateral expansion with which we are immediately concerned.

Wave Action in Relation to Harbour Protection Works—continued

If, for example in fig. 2, the original breadth A_0 of the initial $1_1, 2_1, 3_1, 4_1$, etc., is transformed by frontal expansion to the width A included between 2_s and 3_s and we admit the conservation of the height, sensibly compensated by the two opposing causes which have just been expounded, we obtain the approximate height corresponding to this area by means of the simple expression $A_0\ h_0^2 = A\ h^2$, or, say, $h = h_0 \sqrt{\frac{A_0}{A}}$

In effect, if there were no expansion of the area of the wave $2, 3_1$, in its advance towards $2_s\ 3_s$ and the compensation of heights indicated are verified, the energy of the area corresponding to the length of the wave or to its period $2T = 2T_0$ and situated in the zone $2_s\ 3_s$, would be $E = A_0\ \rho\ g\ L h_0^2$. The expansion causes this energy to be distributed in the breadth A, therefore $E = A_0\ \rho\ g\ L h_0^2 = A\ \rho\ g\ L h_0^2$, whence we deduce the approximate expression previously indicated.

By this procedure, we can obtain, approximately we repeat, all and every one of the mean altitudes corresponding to the areas in which the wave lines are divided by their normals and are enabled to draw the vertical section to the length of the crest of the waves, representing in the stepped form shown in fig. 2′ the mean semi-altitudes corresponding to each area.

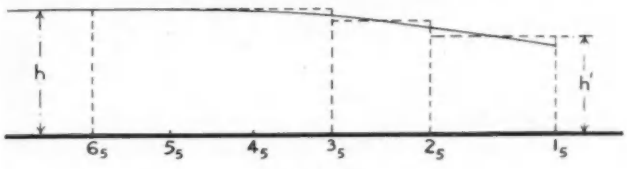


Fig. 2a.

This figure 2′ relates to the wave line $1_s\ 6_s$ of fig. 2, in which in the space $6_s\ 3_s$ is preserved the semi-height of the wave, through having no appreciable expansion. In the spaces $3_s\ 2_s$ and $2_s\ 1_s$ there is reduction of height, which can be determined in the form shown, and that is a consequence of the divergence of the normals which delimit these spaces.

As a second approximation, we make take the stepped representation of heights and continue them as in fig. 2a. We can then obtain as many points as are needed from this curve, sub-dividing in the plane of the wave each area of the parts necessary and drawing the corresponding normals.

Having surveyed all this, we proceed to direct our attention now to two particularly interesing cases.

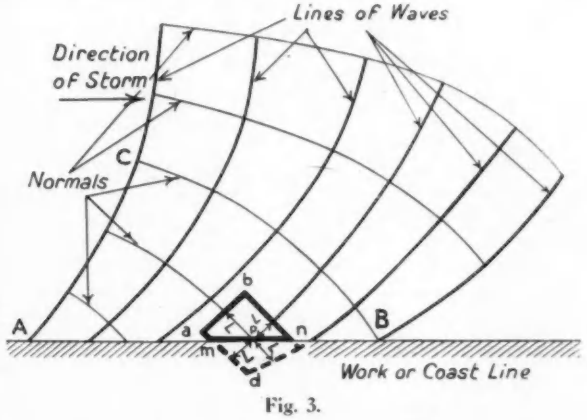


Fig. 3.

In the first place, when the undulation moves forward in a converging direction up to a coast or work, as in fig. 3, it no longer has acceleration in the general manner expressed above, which prompts us to note that it is not the point *A* of the first position of the wave sketched which moves towards *B*, but the point *C* of the wave which in its advance appears at *B*.

In the contrary case, which we call lateral expansion, in order to distinguish it from the frontal expansion already investigated, or it may be when the undulation advances in a direction divergent from the work or coast, tending to separate from it, as happens in fig. 4, the wave setting out from the point *B*, and intersected precisely at *B* by the obstacle, advances, attaining to the normals which we have explained according to the normal line $B\ B_1\ B_2\ B_3$, etc., expanding itself but lacking support in the last intersection towards $B'\ B''\ B'''$, etc., at the cost of the energy given up, in what we can distinguish as the zone of alimentation which extends to $A\ A_1'\ A_2''\ A_3'''$, etc.

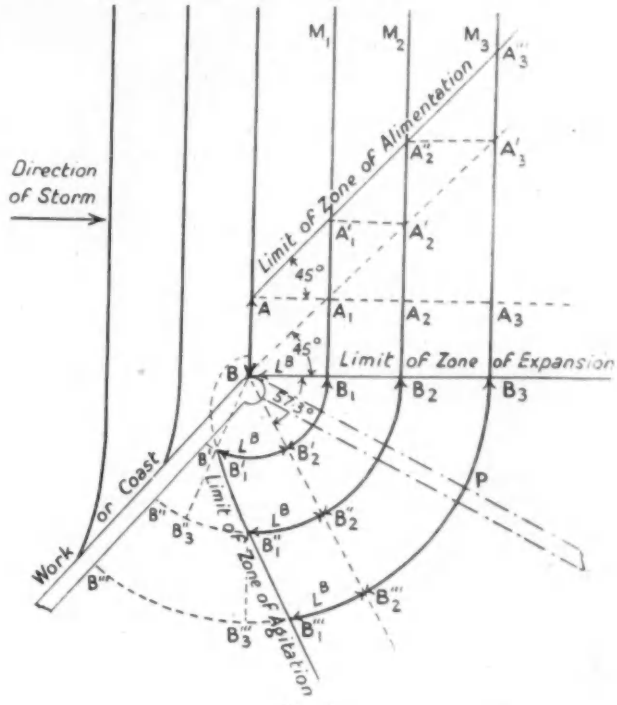


Fig. 4.

In this case, the points $B'\ B''\ B'''$, etc., which it is necessary to locate with care, in order to direct the form of the wave of expansion, are successive points approximately in the line of the advance of the wave, although, as we shall see presently, they are not more, in some cases, than hypothetical, for it happens occasionally that the wave in its lateral expansion does not reach as far as the part which can be called internal of the obstacle constituted by the breakwater or the shore.

From this, we have an idea of the approximate conditions in which the phenomenon develops, and we proceed to observe it with certain attention.

In the position which can be called initial, or say when the crest of the wave comes to coincide in its advance with the extremity of the obstacle *B*, that is when the crest occupies the position *M B*, the preceding trough is in the position $M_1\ B_1$ distant from *M B* half a length (*L*), corresponding to each point, which cannot be equal in all cases, and in the same manner, by means of vertical radials starting from *B* the extreme intersection of the wave, the line of the trough $M_1\ B_1$ will be prolonged in the form $B_1 B'$, the points being distant from *B* the semi-length L_8 corresponding to the zone which rotates round the point *B*.

If, as is frequent in the frontages of our breakwaters, the mean radial depths of the first zone of expansion $B\ B_1\ B'$ are approximately equal, the line $B_1\ B'$ will approximate to the arc of a circle with centre at *B*.

A semi-period, $T = T_0$, later, the crest of the wave will come to occupy the position $M_1\ B_1\ B'$ and subsequently its points will follow, advancing in the normal direction corresponding to each of them in accordance with the rules previously explained, similarly in the zone $M_1\ B_1$ as in that of the expansion $B_1\ B'$.

Wave Action in Relation to Harbour Protection Works—continued

All this, like what follows, is based principally on the fact that the speed of advance of longitudinal waves, $C = \sqrt{\frac{g}{\pi}\frac{L}{K}}$ is solely the function of the semi-length L and of the mean depth of propagation H, previously indicated, and not of the height $2h$ of the wave, and it is based also on the approximate assumption according to which we can agree that waves, transversal to the advance, or, say, those that propagate themselves with the crest of the wave, possess also at each point a speed approximate to that of the longitudinal wave which is propagated in the same depth. Seeing that the original excesses of pressure alongside the vertical which advances with the crest of the wave, by the wave intersected by the obstacle, diminish gradually from the surface of the bottom, it is logical that the transverse molecular speeds will diminish in a similar manner, for it is more than probable that the characteristics of these transverse waves, and among them the speed, approximate to those of the wave of oscillation which generates them.

Although taking into consideration the compulsion, should it be possible, to reach a greater approximation by assimilating these transversal waves of propagation and the release of energy, with other kinds of waves. or taking into account the gyroscopic effect produced by the collapse of the broken wave, it can be admitted that the assumption indicated is acceptable as a first approximation.

Also, it is possible that, setting out from the initial position in which the wave of expansion takes a form sensibly circular, there may be an advance in radial directions, expanding frontally. The differences between the results of this hypothesis and those we have expounded are of very minor importance, because although, according to this one, that which we have defined as the limiting line of the disturbed zone can approximate somewhat more to the part within the breakwater or obstacle, the disturbance produced nearer to this line, determined as its continuation indicates, would be of trifling importance.

It is probable that, generally, the phenomena studied participate in both frontal expansion and lateral cession of energy, the one or the other predominating according to circumstances.

However ready we may be to dispense with them if possible, we will utilise the reduced scale models in order to complete with judicious omissions and not in complete context, each of the interesting extremes to which reference has been made in this study.

Whence comes the energy of the part of the expanded wave comprised between the limits $B B_1$, B_2, B_3, etc., and $B B'_1$, B''_1, B'''_1, etc., in fig. 4? As we have indicated, the formation of this part of the wave is due principally to the vertical lateral of the curtailed wave which advances to the left of the limit of the zone of expansion $B B_1$, B_2, B_3, etc., and, for so much, it is indubitably this zone that proportions the energy required for the generated wave, at its expense, across the said limit and located on its right.

Already in the initial position $M A B$ of the crest of the wave, the formation of the expanded wave of length L_B comprised in B_1, B B', implies a cession or lateral alimentation of energy, which, undoubtedly, originates a diminution of height in the zone next to B as far as $B M$.

It is more than probable that the generation, during the semi-period $T = T_0$ of the said initially expanded semi-wave $B B_1 B'$ may be due to a negative wave, which, during the same period, has advanced from B to A, a length approximating also to L_B, in accordance with the speed of transversal advance above recorded.

In the later advance of the crest of the wave towards the positions $M_1 B_1 B'$ $M_2 B_2 B''$, etc., the limit of the zone of alimentation, or, say of the zone in which the wave loses height by reason of lateral expansion, will be the line $A A'_1 A''_2 A'''_3$, etc., in which $A_1 A'_1$, $A'_2 A''_2$, $A'_3 A'''_3$, etc., will be respectively and approximately equal to $A A_1$, $A'_1 A'_2$, $A''_2 A''_3$, etc. Only in the case in which the depth is constant, this linear limit will be the parallel $A A'''_3$ to the straight line $B A'_3$, which makes an angle of 45° with $B B_3$ and is distant therefrom the semi-length L_B, measured along the crests of the waves.

The energy so dispersed will form the waves previously defined in the plan $B_1 B'_1$, $B_2 B''_1$, $B_3 B'''_1$, the lengths of which along the lines of waves or of crests will be also, respectively and approximately equal to the semi-length L_B, plus the advances $B B_1$, $B B_2$, $B B_3$, etc. If greater precision is desired, in place of adding to L_B the advances in question, there can be given respectively the total advances corresponding to the extremity of the wave, or say, $B B'_1$, $B B'_1 + B'_1 B''_2$, $B B' + B'_1 B''_3 + B''_1 B'''_2$, etc. Also only in case of the depths being constant, the line $B'_1 B'''_1$ will approximate to the parallel of the straight line $B B'''_2$, which makes with $B B_3$ an angle equal to a radian, or say 57.3°, and will be distant therefrom the semi-length L_B measured along the crests of the waves.

Let as take as settled with sufficient approximation the three basic limits which interest us:—

The limiting line of the zone of expansion B, B_1, B_2, B_3, constituted by the normals suitably drawn with care through each one of these points to the wave lines $M B$, $M_1 B_1$ $M_2 B_2$, etc.

The limiting line of the zone of alimentation $A A'_1$ A''_2 A'''_3, etc., in which for example $A'''_3 B_3$ has to be equal to $L_B + AA_1 + A'_1 A'_2 + A''_2 A'_3$.

And the limiting line of the zone of agitation $B'_1 B''_1 B'''_1$, etc., in which, for example, $B_3 B'''_1$ has to be equal to $L_B + B B'_1 + B' B''_3 + B''_1 B'''_3$.

Only, we repeat, in the particular case in which the depth is constant, the three linear limits will be the straight lines $A A'''_3$ and $B B_3$ shown in fig. 4, and the line $B'_1 B'''_1$, which is obtained by adding along the crests to the corresponding points of the straight line $B B'''_2$ the circular arc of constant length L_B. except the variable radius.

In ordinary cases, these limiting lines do not differ much from the three lines so determined.

With this, we have as much as is necessary in order to determine the mean semi-altitude corresponding to each position of the wave in the zone influenced by the lateral expansion, because if, for example, the position $A'''_3 B'''_1$ in fig. 4 interests us, we obtain its semi-altitude h' represented in fig. 4, by means of the simple expression $h' = h\sqrt{\frac{A'''_3 B_3}{A'''_3 B'''_1}}$, in which h is the mean semi-altitude corresponding to the zone of alimentation $A'''_3 B_3$.

It is necessary now to pass from the stepped representation of heights to its continuation more closely to actuality.

In the general case similar to fig. 4, in which the interior line of the work or coast-line producing lateral expansion remains outside the linear limit of the disturbed zone, the expansion is total.

In this general case and if, as is very frequent, the depths which the lines of waves encounter in their advance are not very different from the lengths of each of them, the energy represented by the rectangle $A'''_3 B_3 B A_1$, of length $A = A'''_3 B_3 = B_3 B'''_1$, in fig. 4 is distributed in the rectangle $A'''_3 B'''_1 B_1 A'$, of double length $2A = A'''_3 B'''_1$, or with closer approximation to reality, in the sinusoidal quadrant $A'''_3 B'''_1 B' A_1$ of the same length $2A$, and that can very well be the continuous representation of the semi-heights of the expanded wave, since the energy represented in the said rectangle $A'''_3 B_3 B A_1$ is equal to the said corresponding sinusoidal quadrant $A'''_3 B'''_1 B' A_1$ of double length.

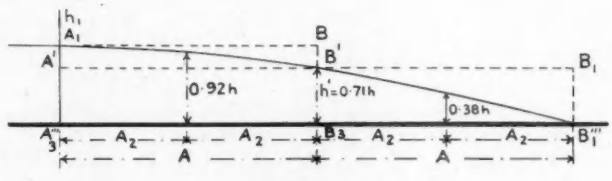


Fig. 4a.

In effect: if $h_1 = h \sin \alpha$ represents the sinusoidal law of variation of semi-altitudes, corresponding to the stated sinusoidal quadrant, of length $2A$ in fig. 4a, it will be necessary to examine

Wave Action—continued

the relationship $\frac{x}{2A} = \frac{\alpha}{\frac{\pi}{2}}$; whence $\alpha = \frac{\pi x}{4A}$ $y\,dx = \frac{4A}{\pi}\,d\alpha$.

In consequence of this we have

$$\int_0^{2A} h_1^2\,dx = \int_{\frac{\pi}{2}}^{\pi} (h \sin\alpha)^2\,d\,x = \frac{4\,A}{\pi} h^2 \int_{\frac{\pi}{2}}^{\pi}$$

$$\sin^2\alpha\,d\,\alpha = \frac{4\,A}{\pi} h^2 \left(-\frac{1}{4} \sin 2\,\alpha + \frac{1}{2}\,\alpha \right)_{\frac{\pi}{2}}^{\pi} = A\,h^2$$

whence the energy represented by the sinusoidal quadrant $\rho g L \int_0^{2A} h^2_1\,d\,x$ is equivalent to that corresponding to the rectangle $\rho\,g\,L\,A\,h^2$. This sinusoidal quadrant with its maximum at A_1, or say in the point corresponding to the limit of the zone of alimentation, passes through B', or say the point corresponding to the limit of the zone of expansion and situated in the rectangle of the stepped representation of heights.

In almost all the remaining cases, inclusive of that which on account of the direction of the breakwater, such as the $B\,P$ of fig. 4, does not permit of the total expansion of the extremity of the wave, the method described can generally be adopted, introducing likewise as continuous representation of the semi-altitudes, the sinusoid which, originating horizontally at the semi-altitude h, above the limit of the zone of alimentation, passes through the point analogous to B', determined previously and also situated above the limit of the zone of expansion, at the semi-altitude corresponding to the stepped representation of semi-altitudes corresponding to this case. In order to determine it, it suffices to substitute in the simple expression previously indicated, $A'''_3\,P$ in place of $A'''_3\,B'''_1$, from which it results that $h' = h \sqrt{\frac{A'''_3\,B_3}{A'''_3\,P}}$, which permits us to locate the point similarly to B', which defines the sinusoid sought.

On the basis of the theories expounded, the good sense of the designer will enable him to resolve the different and innumerable special cases which can arise and which it would be absurd to endeavour to include in a general investigation such as the present one.

We have then resolved with a certain approximation, even when lacking in methods of definite solution, the interesting problem set out.

Before closing, we have to assert once more that we do not claim to have reached precise solutions, perhaps, much less; but we believe we have arrived at a degree of approximation sufficient for the majority of practical cases and similar to the attainment of many of the solutions adopted for land engineering.

We hope to refine further this method of wave plans as a consequence of theoretical-practical studies since undertaken, and if, as we have indicated, experiments with reduced scalar models are applicable with difficulty to complete cases in general, we estimate them as of inappreciable utility for pursuing the refinement of simple, although interesting and instructive particular cases, judiciously condensed, on which account we continue to use the said reduced models, however ready we may be to dispense with them.

Probably observations in the real sea will also be of great utility if it can be established that through using them to the extent in which they can throw light on these interesting theories, we can enlist the co-operation of as many collaborators as possible who will interest themselves in them, not as subjects for polemics, generally futile and over-passionately applied, but in the more modest and efficacious co-operation in which the observations which confirm and also those which tend to modify or refine the ideas expressed are equally of service.

(To be continued)

Notable Port Personalities

XXVII—Sir Frederick J. West, C.B.E., J.P.

Sir Frederick Joseph West, C.B.E., J.P., Chairman of The Manchester Ship Canal Company and a Director of that Company—the Port Authority for Manchester—since 1917, is strongly entrenched in the industrial and business life of Lancashire and has a record of public service extending over thirty years as Councillor and Alderman of the City of Manchester, holding the Lord Mayoralty in 1924-25. In the municipal field he has identified himself closely with the progress of technical education.

SIR FREDERICK J. WEST, C.B.E., J.P.

Sir Frederick is a member of both the Institution of Civil Engineers and the Institution of Mechanical Engineers, and his services as an engineer have been much sought and generously given both in the Lancashire industrial area and in the wider national sphere.

In the last war he was a member of the Manchester Armaments Committee and in the present war he held the Chairmanship of the North-Western Regional Board from its inception until recently, when this office became a full-time appointment. He remains on the Board as vice-chairman, and he is also a member of the Advisory Committee to the Minister of Production.

He has held the Presidency of the Manchester Engineering Employers' Association for two years and has been honoured by the Franklin Institute of Pennsylvania for original and notable work in the Gas Industry.

He has travelled extensively and displays a wide and tolerant view of men and affairs.

As a member of three engineering institutes his technical qualifications rank high and it is becoming that he should hold the Chairmanship of an undertaking which occupies an unchallenged position among the most interesting and courageous major enterprises of its kind successfully carried out in this country.

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this Journal should not be taken as an indication that they are necessarily available for export.

Notes of the Month

Proposed Foreign Trade Zone at Houston.

An application has been put forward by the Port Commission at Houston, Texas, U.S.A., for the establishment of a Foreign Trade or Free Port Zone at the port.

Extension of Berthage at Mombasa.

The local Harbour Advisory Board has recommended to the Kenya Government that two additional deep-water berths should be constructed at the port, at an estimated cost of £354,000.

Pilotage Conference.

The 56th conference of the United Kingdom Pilots' Association is being held in London on September 30th and October 1st. Among the questions to be raised are post-war pilotage problems, pilotage rates, pilot benefit funds and pilot cutters.

New Port in Persian Gulf.

The American press announces active constructional operations in progress at a new port in the Persian Gulf for the reception of shipping engaged in the supply of munitions to Soviet Russia from the United States.

Proposed Tay to Clyde Canal.

The proposal put forward by Capt. Ramsay, M.P., for Peebles, that a canal be constructed to link the rivers Tay and Clyde, has been negatived on the ground that a project of this kind would require preliminary survey work which could not be undertaken at the present juncture.

Port of Goole Pilotage Rates.

At a meeting of the Humber Conservancy Board on 22nd September it was decided in conformity with the wishes of the United Kingdom Pilotage Association and the Chamber of Shipping to continue the present temporary increase of 33⅓rd per cent in Goole pilotage rates until the end of the current year.

Death of Former Harbour Commissioner.

The death on August 29th has been announced of Mr. Thomas R. Burns, who, until his retirement in 1941, was for 17 years a member of the Belfast Harbour Commission. A leading accountant in the city, Mr. Burns' services were of great value to the Commission, to which he gave attention for many years after giving up active work in his profession.

Cape Town Harbour Development.

The new basin at Cape Town has been named the Duncan Dock in honour of the Governor General of the Union. It comprises the whole of the enclosed harbour area extending each of the South Pier as far as the yacht harbour. The size of the Duncan Dock may be judged from the fact that it is four times larger than the combined areas of the Alfred and Victoria Docks at the same port.

Bombay Port Trust.

At the meeting on 3rd July (the latest of which a report has reached this Journal) the chairman informed the Board that the accounts for the year ended 31st March, 1942, had been closed and showed a surplus of Rs. 92.86 lakhs, including Rs. 1.07 lakhs under Pilotage Account. Mr. G. E. Terrey, M.Inst.C.E., has been confirmed in the post of Chief Engineer to which he had been provisionally appointed.

Port Clearance Order in Northern Ireland.

The clearance of merchandise at ports has been the subject of a Statutory Order of the Northern Ireland Ministry of Commerce made under the Defence Regulations, by which all engaged in business are required to make arrangements to receive and to provide reasonable facilities for receiving such merchandise as may be tendered to them by shipping companies, railways, or the Road Transport Board, between 9 a.m. and 8 p.m. Where delivery is to be made at a time when premises, in the ordinary course of business, would be closed, notice must be given before noon. The order is cited as the Clearance of Merchandise at Ports (Northern Ireland) Order, 1942.

Industrial Expansion at Peruvian Port.

The Government of Peru have signed a contract for the construction and development of iron and steel works at the Port of Chimbote which lies rather more than 200 miles North of Lima, the capital.

Record Ore Discharge at Great Lakes Port.

It is announced that the ore boat *Leon Fraser*, belonging to the Pittsburg Steamship Company, recently unloaded 16,514 gross tons of iron ore at the Port of Conneaut, this being the largest cargo ever discharged at a Lake Erie port.

Lengthening of Swedish Naval Graving Dock.

It has been decided by the Swedish Riksdag that the Gustaf V graving dock on the outskirts of Stockholm shall be lengthened at a cost of about one million kroner. The dock in its present form dates from 1923, when it was constructed to a length of 140 metres at a cost of 4,085,000 kroner.

Distinction for Port Official.

Mr. J. T. Edmunds, dock manager at Newport, has been placed on the Commission of the Peace. He has been associated with port administration since 1905, having served at Port Talbot and Swansea in addition to Newport. He is a member of the Newport Harbour Commission and chairman of the Newport Port Emergency Committee.

Port of New York Authority Appointments.

Following the retirement of Mr. John E. Ramsay, general manager, and Mr. Julius H. Cohen, general counsel, the Port of New York Authority has appointed Mr. Austin J. Tobin as executive director and Mr. Leander I. Shelley as general counsel. Both Mr. Ramsey and Mr. Cohen are being retained by the Authority in a consulting and advisory capacity.

Death of Retired Port Official.

It is announced that the death has occurred in hospital of Mr. Joseph Little, of North Shields, who until his retirement in February last, had held the position of chief clerk with the Tyne Improvement Commissioners. He entered the service as a boy in the Traffic Department at Northumberland Dock and the total duration of his employment was 52½ years.

Diversion of Exports from United States Ports.

The United States Board of Economic Warfare has advised American exporters of its intention to route commodities destined for off-shore shipment through ports where congestion is not great, even though the ports may be some distance off the direct route of shipment. A choice of ports, it is stated, has been found a necessary consideration in the control of transportation of materials destined for foreign countries.

Appointment of Dry Docks Manager.

Mr. Harry C. Bustard has been appointed general manager of the Mercantile Dry Dock Company, Ltd., at Jarrow. Mr. Bustard, a native of Liverpool, who served an apprenticeship with Smith's Dock Company, Ltd., at South Bank, after going through the drawing office, was appointed assistant dock manager. Subsequently he served in China, with the Taikoo Dockyard and Engineering Company, Ltd., of Hong Kong.

Smoking Regulation on Merseyside.

The Mersey Docks and Harbour Board have just passed a new by-law, by which permission is given for smoking in various places within the dock estate, subject to the absence of a notice to the contrary and unless certain goods are in the vicinity. The places include residences, offices, canteens refreshment rooms, some slaughter houses, roadways and open quays free of certain bulk cargo, and the cabins or living rooms of a vessel not carrying petrol. Smoking has hitherto been generally prohibited, but there has been surreptitious practice of the habit and it is hoped that the new regulation will reduce this, by allowing smoking in places where the risk of fire is negligible.

The Depreciation and Maintenance of Cargo Handling Plant at Ports.

By S. HOWARD WITHEY, F.C.I.

Assessment of Annual Depreciation

In normal times, the highest value that can be placed on cargo handling plant is the cost of acquiring the various installations, plus transport charges, foundation and installation expenses, while the lowest value is the value of the material, parts, attachments and devices, less dismantling costs and selling expenses. Consequently, the assessment of the annual depreciation charge is often based on the difference between these extreme figures, with due regard to the conditions under which particular equipment is to be operated. Under existing conditions, however, the wear and tear on moving parts and accessories is much greater than in normal times, and while some units of plant give very satisfactory service over extended periods, others cannot realise their expected length of working life owing to the great increased speed at which the machinery is called upon to work.

The majority of engineers fully realise that accurate and reliable costs cannot be compiled unless adequate sums are charged for the decrease in the capital value of plant due to wear and tear, obsolescence, and effluxion of time. At the same time, there is still considerable difference of opinion as to the correct methods to be adopted for the computation and recording of depreciation and maintenance charges. Some engineers, for instance, insist that so long as the full cost of repairs, upkeep and replacement is debited against the operations, the final accounts should not be further burdened with a charge under the heading of depreciation, and owners of harbours and docks as well as lighterage and other contractors are inclined to regard as meaningless the valuations which are placed on loading and discharging gear unless the final figures bear some very direct relationship to prevailing market values.

In this important matter, the general position is rendered more difficult by reason of the fact that the methods of exercising a physical control over the various units and sections of plant differ widely. Apart from the factor of economy of operations, all decisions regarding the installation of new or additional handling equipment are governed in such large measure by the efficiency of the assets previously used that suitable records must be kept on the spot if the amount and the right type of information is to be provided.

In order to be of real practical utility, therefore, all equipment of the same type or which is used for similar purposes should be grouped together for separate treatment, the totals being summarised to show the precise number of units of each class or description, also all variations which may have taken place during the particular financial or working period. In some cases it may be discovered that the number of mechanical appliances in operation at a particular place is greater than is called for, having regard to the volume of incoming and outgoing cargo to be dealt with; in other cases, it may be proved that speed and general efficiency are being seriously retarded by the continued employment of unsuitable types of plant, or by an insufficiency of the right types. It is certain that by keeping proper records of the capital outlay and of the progress of different installations, any necessary or desirable changes can be effected in good time, and the cargo handling facilities very materially improved in one way or another. By rearranging some of the plant, it is often possible to reduce the operating costs substantially, and to instal the bulk of the equipment to better advantage, and recent experience has proved quite conclusively that where elevators and conveyor equipment and auxiliary hoisting and lowering machines are subjected to a systematic control much more satisfactory results are obtained than is possible when no organised attempt is made to exercise a check over the assets employed.

Card Records

It is because machinery and plant records greatly facilitate the determination of depreciation at any time, and enable the amount of unrecovered investment to be ascertained without delay, that detailed and elaborate records are now being kept at some ports. These records usually take the form of cards which have been suitably ruled and printed for the purpose, and which can be maintained in alphabetical or any other convenient sequence. At the top of each card, sufficient space can be reserved for the insertion of such particulars as the location of the unit or section of equipment, the constructor's name and number, the nature of the attachments, etc., columns or sections being also provided for recording the cost of acquisition, the transport charges, installation expenses, foundation charges, and the cost of gadgets and special devices, also for the periodical valuations.

Several patterns and styles of card are in use at the present time, one of the most useful having rulings on the back for inserting the opening capital value, the amount of depreciation written off during the last financial period, the diminished book value, and the cost of any additions or improvements made during the year. This gives the correct figure for balance sheet purposes, although, of course, if the double account system is employed, the original capital and additions will be regarded as sunk for all time, and the more liquid position will be dealt with separately. A typical pattern of card capable of modification to satisfy any special requirement is indicated below:—

PLANT RECORD.

TRAVELLING CRANE.

Description : .....
Location : .....
Constructor's Name .....No.....Span.....ft.....ins.
Attachments : .....
.....
Hoisting Motor.....H.P.....R.p.m.
Motor for Auxiliary Hoist.....H.P.....R.p.m.
Motor for Longitudinal Travel.....H.P.....R.p.m.
Motor for Cross Travel.....H.P.....R.p.m.
Construction : .....
Designed for.....Suitable for.....
Order No. .....Date Installed .....19.....Rate of Depreciation.....%

Date.	Ref.	Details of Cost.		Remarks.
		Acquisition.....		
		Transport		
		Installation		
		Foundation		
		Attachments		

(Back of Card).

				Date.	Repairs.	Cost.
Value as at .....19.....						
Less Depreciation written off.....						
Diminished Value.....						
Additions						
Value as at .....19.....						
Less Depreciation written off..... ..						
Diminished Value.....						
Additions						
Value as at 19						
Less Depreciation written off						
Diminished Value.....						
Additions						
Value as at 19						
Less Depreciation written off						
Diminished Value.....						
Additions						

Depreciation and Maintenance of Cargo Handling Plant at Ports—continued

Installation expenses are usually written off on a basis different from that applied to the plant itself, consequently it will be found more useful to show details of the cost instead of lumping the items together under one general heading. The cards should be kept in a drawer where they can easily be maintained in position by means of a steel rod or other similar device, and by using a special form of card the records can be summarised in the form of sectional totals, if required.

Broadly speaking, there are two methods of recording the capital cost of cargo-handling plant. The original items may be posted direct from the cash book to the debit side of the appropriate asset account, or the invoiced prices may be extended into the capital outlay column of the purchases journal. In the former case, the ledger entry will give the date of payment—which is not necessarily the same as the date of acquisition or installation—whereas the monthly or other period totals of the capital outlay sections of the book of original entry will have to be dissected in order to determine the correct figure to transfer to each asset account.

The replacement of old hoists by modern handling appliances calls for the making of records giving effect to the retirement of the old and the installation of the new. A number of small units may be replaced by larger equipment possessing a greater operating efficiency at a lower cost, the debit balance of the old account being then written off and the total cost of the new equipment capitalised by means of a direct posting. Sums realised upon the sale of old plant or from the disposal of parts may be credited to the asset account before the balance is written off.

Although maintenance costs vary very considerably at different ports, fluctuations in the annual charge for upkeep and repairs can be avoided by estimating the total cost over the period of service life. This figure plus the original capital cost will give the sum to be divided by a definite number of years to arrive at the amount to be incorporated in costs, the expenditure actually incurred on upkeep and repairs being charged against a reserve. In this connection it is advisable to distinguish between daily repairs and adjustments of a relatively trivial nature and the larger maintenance jobs.

Capital Values

The amount of capital invested in mechanical appliances and auxiliary equipment for the efficient handling of cargo is, of course, very considerable, and while the various items of capital outlay are usually dealt with in a proper manner in the books of account, the methods adopted for the computation and recording of depreciation are sometimes unsuitable and very misleading.

Decline of capital value is frequently the result of actual physical deterioration. It may be caused, however, by developments in design and construction which have the effect of rendering obsolete, not only individual units of equipment, but entire cargo-handling installations, while variations in the value of specific groups of plant as determined by the operation of the ordinary law of supply and demand may prove to be of permanent nature. But whatever the actual cause may be, it is of the utmost importance that all shrinkages should be correctly computed and recorded, and that an adequate charge should be made for depreciation in the costs and in the final accounts.

Straight Line Method

In those instances where the cost of repairs is not likely to increase materially, as time goes on, an equal proportion of the total capital cost should be written off each year in such a way that at the end of the period of service or useful life of the plant, the book value will be either extinguished or reduced to a purely nominal figure.

This is usually referred to as the " Straight Line " method, and is very simple to apply. If, however, the costs of upkeep and maintenance show a definite tendency to expand with a diminished efficiency of the equipment, it is advisable to adopt a method which would equalise the combined charge over a given period.

In illustration of the procedure and principles involved in the practical application of the " straight line " method, let it be supposed that on balancing the accounts as at the end of December last as a necessary step in the direction of the drafting of a balance sheet exhibiting a true and correct view of the financial position, the directors of a company specialising in the handling of cargo to rail and road vehicles, discover the handling plant and auxiliary mechanical appliances to have a value of £30,000. (This figure is taken simply for convenience). As the equipment was installed many years ago, since when many developments and improvements in design, construction and capacity have taken place, it is anticipated that in order to increase the handling facilities all the plant will have to be replaced in five years' time by new and more efficient installations. If it is desired to spread the burden evenly over this period and to show a residual value of £15,000, the sum of £3,000 would have to be written off each year, but if any capital additions are made during the period of five years the assessment of depreciation would be complicated by variations in the length of service life of the additional plant.

We will suppose, therefore, that units or groups of new cargo-handling plant and attachments are installed by the same company at different ports during the period, as follows:—

Jan., 1942—Capital outlay, £20,000. Plant estimated to last 20 years.
Jan., 1943—Capital outlay, £16,000. Plant estimated to last 20 years.
Jan., 1944—Capital outlay, £6,000. Appliances expected to last 15 years.
Jan., 1945—Capital outlay, £,000. Machines estimated to last 20 years.
Jan., 1946—Capital outlay, £5,000. Gear estimated to last 25 years.

The sums to be charged each year under the heading of depreciation would then have to be determined by means of the following computations:—

Year Ending December, 1942—

	£
One-fifth of £15,000 (viz.: £30,000 less £15,000)	3,000
One-twentieth of £20,000	1,000
Depreciation	£4,000

Year Ending December, 1943—

One-fifth of £15,000	3,000
One-twentieth of £20,000	1,000
One-twentieth of £16,000	800
Depreciation	£4,800

Year Ending December, 1944—

One-fifth of £15,000	3,000
One-twentieth of £20,000	1,000
One-twentieth of £16,000	800
One-fifteenth of £6,000	400
Depreciation	£5,200

Year Ending December, 1945—

One-fifth of £15,000	3,000
One-twentieth of £20,000	1,000
One-twentieth of £16,000	800
One-fifteenth of £6,000	400
One-twentieth of £8,000	400
Depreciation	£5,600

Year Ending December, 1946—

One-fifth of £15,000	3,000
One-twentieth of £20,000	1,000
One-twentieth of £16,000	800
One-fifteenth of £6,000	400
One-twentieth of £8,000	400
One-twenty-fifth of £5,000	200
Depreciation	£5,800

Losses due to obsolescence are not affected by reason of variations in the effective life of individual units, and instead of providing for depreciation in a variable or casual manner, the figures should be determined in accordance with a definite scale. When plant is installed to meet a temporary demand for handling facilities, the fixed charges applicable to that plant may be charged against specific operations in preference to burdening the entire plant layout. New uses and wider exploitation may cause additional machinery to be installed for occasional use, and neither from the engineering nor the accounting standpoint can an increase in general handling costs always be justified.

Depreciation and Maintenance of Cargo Handling Plant at Ports—continued

Percentage Method

Under existing conditions, it is advisable to ensure, as far as possible, that the combined charge for depreciation and maintenance does not press too heavily during any given operating period, and by adopting the "Percentage" method the balance of unrecovered investment, as at the beginning of each financial year, can be subjected to deduction at a fixed rate per cent., the progressive decline in the depreciation charge providing the margin required to meet growing upkeep costs.

For example, assume that additional units of handling plant were installed in December last at a total cost of £12,500, made up as follows:

Elevators costing £4,855, and estimated to possess a value of £1,000 at the end of 15 years.
Conveyors costing £4,080, and estimated to be worth £1,500 in 12 years' time.
Trucks costing £3,000, having an estimated scrap value of about £590 at the end of 10 years.
Auxiliary equipment costing £565 and estimated to possess a residual value of £200 at the end of 11 years.

In applying the "straight line" method, the figure of annual depreciation would be arrived at as follows:—

	£
Elevators—	
One-fifteenth of £3,855 (viz.: £4,855 less £1,000)	257
Conveyors—	
One-twelfth of £2,580 (viz.: £4,080 less £1,500)	215
Trucks—	
One-tenth of £2,410 (viz.: £3,000 less £590)	241
Auxiliary Equipment—	
One-eleventh of £365 (viz.: £565 less £200	33
Depreciation	£746

On the assumption that the planning department had budgeted for an increase in maintenance charges from £500 to £650 for the first two years, and from £780 to 900 for the next two years, the result would be as follows:—

	Depreciation £	Maintenance £	Total £
First Year	746	500	1,246
Second Year	746	650	1,396
Third Year	746	780	1,526
Fourth Year	746	900	1,646

Variation in the total charge from £1,246 to £1,646 could be avoided by applying the "percentage" method, the only real difficulty being to determine the precise percentage rates to be employed to produce the desired results. In this connection, the following table giving the total amount which would be written off in a given number of years when plant is subjected to depreciation at the rate of from 6 per cent. to 10 per cent. on diminishing book values will be found useful:—

DEPRECIATION TABLE FOR CARGO-HANDLING PLANT.

Years	6 per cent.	7 per cent.	8 per cent.	9 per cent.	10 per cent.
1	6.00	7.00	8.00	9.00	10.00
2	11.64	13.51	15.36	17.19	19.00
3	16.94	19.56	22.13	24.64	27.10
4	21.92	25.19	28.36	31.42	34.39
5	26.61	30.43	34.09	37.59	40.95
6	31.01	35.29	39.36	43.21	46.86
7	35.15	39.84	44.21	48.32	52.17
8	39.04	44.03	48.67	52.97	56.95
9	42.70	47.97	52.78	57.20	61.26
10	46.14	51.61	56.56	61.06	65.13
11	49.37	55.00	60.03	64.56	68.62
12	52.41	58.15	63.23	67.75	71.76
13	55.26	61.08	66.17	70.65	74.58
14	57.95	63.80	68.87	73.29	77.12
15	60.47	66.33	71.37	75.70	79.41
16	62.84	68.69	73.66	77.88	81.47
17	65.07	70.88	75.77	79.87	83.32
18	67.16	72.92	77.70	81.68	84.99
19	69.14	74.81	79.48	83.33	86.49
20	70.99	76.58	81.12	84.83	87.84
21	72.73	78.22	82.63	86.20	89.06
22	74.36	79.74	84.02	87.44	90.15
23	75.90	81.16	85.30	88.57	91.14
24	77.35	82.48	86.48	89.60	92.02
25	78.71	83.71	87.56	90.53	92.82

It will be seen that in the case of the elevators, the amount of £3,855 to be written off in 15 years would represent nearly 80 per cent. of the capital cost, consequently 10 per cent. of the diminishing book value would be written off each year. In the case of conveyors the rate would be 8 per cent., but in the case of the trucks it would have to be 15 per cent., while the auxiliary equipment would be subjected to annual reductions of 9 per cent., the computations for the first four years being made in the manner indicated below:—

	£
First Year—	
10 per cent. of £4,855	486
8 per cent. of £4,080	326
15 per cent. of £3,000	450
9 per cent. of £565	51
Depreciation	£1,313
Second Year—	
10 per cent. of £4,369 (viz.: £4,855 less £486)	437
8 per cent. of £3,754 (viz.: £4,080 less £326)	300
15 per cent. of £2,550 (viz.: £3,000 less £450)	382
9 per cent. of £514 (viz.: £565 less £51)	46
Depreciation	£1,165
Third Year—	
10 per cent. of £3,932 (viz.: £4,369 less £437)	393
8 per cent. of £3,454 (viz.: £3,754 less £300)	276
15 per cent. of £2,168 (viz.: £2,550 less £382)	325
9 per cent of £468 (viz.: £514 less £46)	42
Depreciation	£1,036
Fourth Year—	
10 per cent. of £3,539 (viz.: £3,932 less £393)	354
8 per cent. of £3,178 (viz.: £3,454 less £276)	254
15 per cent. of £1,843 (viz.: £2,168 less £325)	276
9 per cent. of £426 (viz.: £468 less £42)	38
Depreciation	£922

The burden would then be much more evenly distributed over the period, as demonstrated below:—

	Depreciation £	Maintenance £	Total £
First Year	1,313	500	1,813
Second Year	1,165	650	1,815
Third Year	1,036	780	1,816
Fourth Year	922	900	1,822

At the termination of each financial year, the amount to be written off would be recorded on the credit side of the plant account (except where the double account system is operated) and debited to the depreciation account, the balance of which would appear as a charge against revenue. The amounts written off in this way would steadily diminish, the reduction providing the margin needed to meet the expanding maintenance charges, and at the end of a period of 10 years the asset account would show the following figures:—

CARGO HANDLING PLANT.

Debit.	£	Credit.	£
1941.		1942.	
Dec. To Capital Cost ...	12,500	Dec. 31 By Depreciation written off ...	1,313
		Dec. 31 By Balance ...	11,187
	£12,500		£12,500
1943.		1943.	
Jan. 1 To Balance ...	11,187	Dec. 31 By Depreciation written off ...	1,165
		Dec. 31 By Balance ...	10,022
	£11,187		£11,187
1944.		1944.	
Jan. 1 To Balance ...	10,022	Dec. 31 By Depreciation written off ...	1,036
		Dec. 31 By Balance ...	8,986
	£10,022		£10,022
1945.		1945.	
Jan. 1 To Balance ...	8,986	Dec. 31 By Depreciation written off ...	922
		Dec. 31 By Balance ...	8,064
	£8,986		£8,986

Depreciation and Maintenance of Cargo Handling Plant at Ports—continued

1946.			1946.		
Jan. 1 To Balance	...	8,064	Dec. 31 By Depreciation written off	...	822
			Dec. 31 By Balance	...	7,242
		£8,064			£8,064
1947.			1947.		
Jan. 1 To Balance	...	7,242	Dec. 31 By Depreciation written off	...	734
			Dec. 31 By Balance	...	6,508
		£7,242			£7,242
1948.			1948.		
Jan. 1 To Balance	...	6,508	Dec. 31 By Depreciation written off	...	655
			Dec. 31 By Balance	...	5,853
		£6,508			£6,508
1949.			1949.		
Jan. 1 To Balance	...	5,853	Dec. 31 By Depreciation written off	...	584
			Dec. 31 By Balance	...	5,269
		£5,853			£5,853
1950.			1950.		
Jan. 1 To Balance	...	5,269	Dec. 31 By Depreciation written off	...	524
			Dec. 31. By Balance	...	4,745
		£5,269			£5,269
1951.			1951.		
Jan. 1 To Balance	...	4,745	Dec. 31 By Depreciation written off	...	469
		£4,745	Dec. 31 By Balance	...	4,276
					£4,745
1952.					
Jan. 1 To Balance	...	4,276			

The balance of £4,276 then shown in the account would represent the following:—

	£
Elevators (having 5 years to run)	1,693
Conveyors (having 2 years to run)	1,773
Trucks	590
Auxiliary Equipment	220
	£4,276

The general conclusion to be drawn is that the " percentage " method of computing and recording depreciation should be adopted when, as is the case with cargo-handling plant, costs of maintenance show a definite tendency to grow.

Correspondence

To the Editor of "The Dock and Harbour Authority."

British Canal Traffic

Sir,—

In a letter published in your August issue, I made a comparison between Continental Canals and Regulated Rivers, and those in this country—a comparison which, unfortunately, shows our great shortcomings. I compared also rates of freight, and went on to show how Continental manufacturers, on account of the well-developed canal systems in their countries, can avail themselves of inland freights which are considerably cheaper than those our industries have to pay.

It is interesting to see from recent publications in the press that the Axis countries are already planning to pursue an active policy for intensive development of waterways, linking up Germany with the Danube countries and Italy.

I am afraid that previous Governments in this country made a serious mistake when the building and development of canals was left to public companies. I consider that a canal, like a river and a road, is a public highway.

The Continental countries, our competitors in the economic field, were apparently never in any doubt about this point. Their canals are Government-owned. It is obvious that Governments, with their wider powers to overcome obstacles and their greater financial resources, should undertake such enterprises. Tens of thousands of men would have found employment, instead of living on the dole and idling their time away.

It has been argued, long before the war, that a canal should be constructed for seagoing vessels from the Solway Firth to the North Sea. In my opinion, this was essentially a Government matter, considering the great strategic value of such a canal, quite apart from its value from a commercial point of view Its value for Great Britain can almost be compared to the Kaiser Wilhelm Canal's value for Germany. It certainly would have saved us very many vessels, which now on their tedious journeys round our island, have been lost through enemy action.

It is an example of what was left undone, because the Government probably waited for a company to do the job.

Companies can be bought up by other transport systems in order to eliminate competition. Yet, it is sound competition that we want. There should be keen competition between rail, canal and road transport in the interest of the industry.

Great Britain, impoverished by the war, will have to export in order to maintain its standard of life. Our exports have either declined or not grown fast enough, and this has led to the position that Great Britain imported almost twice as much as it exported. If our position as a creditor country in the past allowed us to carry this heavy burden, the position after the war will almost certainly not allow it.

The Government using its emergency powers, should take over the canals from their present owners, and reorganise and develop them, in order to make them at least as efficient as the canals of our Continental competitors.

Several canals should have a minimum width of 60-ft. and a depth of 10-ft. There should be very many fewer locks and those locks should be able to accommodate vessels of 160-ft. in length. This would allow Diesel motor-driven barges of some 600 to 800 tons to be used on those canals, and it would allow our efficient motor coasters with their collapsible masts and funnels to proceed straight from sea to industrial centres in the interior, cutting out costly handling and trans-shipment expenses in sea ports and speeding up transport.

It would bring inland transport costs down to a level, comparable with those on the Continent, and it would give a chance to a vast fleet of river and canal craft to grow up, giving work also to our shipbuilding yards and Diesel engine manufacturers.

In face of what is happening in the world to-day, it is fully time to do away with complacency and to realise that we shall have to make ourselves ready for a bitter economic struggle after the war. Out-of-date systems should be transformed into smooth running up-to-date machinery.

Inland transport is one of the systems which badly needs overhauling and transformation.

I hope that you will permit me to write you a further letter on the subject of inland navigation, which in Holland has been almost brought to perfection.

Yours truly,
" JACK HOLLAND."

London.
1st September, 1942.

Dock Strike at Liverpool.

An unofficial dock strike at the Port of Liverpool, which involved the loss of 3,000 hours of working time, took place in the early days of September. It was settled after an hour's discussion between the Trade Union officials and the Regional Port Director. Subsequently, Mr. Fred Smith, the district secretary of the Transport and General Workers' Union, visited the dockers working on every ship in the strike area and also the canteens in the district. At each place he pointed out in very strong terms that illegal strikes, besides impeding the National war effort, prevented the Union from helping its members. " If you have a genuine grievance," he said, " bring it to your union officials immediately, but do not stop work, no matter how real your grievance may be. We cannot negotiate if you illegally stop work."

Destruction of Timber by Marine Organisms in the Port of Sydney

Excerpts from Supplementary Report No. 2

By Messrs. R. A. JOHNSON and F. A. McNEILL.

(Concluded from page 116)

Impregnated Sassafras Timber ("Doryphora Sassafras") Results of Recent Test

With the employment of the hot and cold open tank method of impregnation, using creosote, Sassafras timber has proved itself an incomparable medium. It excels in the matter of uniform penetration and amount of absorption, exhibiting these qualities far in advance of any other of the softwoods tested locally (including oregon fir and hoop pine). Because of these attributes, impregnated Sassafras was expected to show marked resistance to marine borer destruction.

Casing of Sealing Compound round a turpentine pile in 18-ft. of water at low tide, Bantry Bay, Middle Harbour. The photo shows the casing receding down through the clear water from near low tide level. A few inches depth of water is over the top of the finished work.

A special test carried out at Manly (Station No. 32) was initiated in 1935, when a standard 3-in. by 3-in. by 5-ft. sample, carrying eight pounds of creosote, was immersed. The latest inspection, made 5 years after the date of immersion, did not disclose the presence of any marine borer attack. This result was most satisfactory in view of the fact that the Manly test station has registered the most intense attack of *Cobra* borers in the Port of Sydney.

On the occasion of the inspection referred to, the quantity of creosote still retained in the sample was evidenced by its noticeable presence on the surface of the timber.

A separate test to determine the rate of leeching has been inaugurated in collaboration with the Division of Forests Products of the Commonwealth Council for Scientific and Industrial Research. Although as yet incomplete, the results point to a very light rate of loss.

The discovery of Sassafras as a medium for impregnation with creosote opens the way for its use in many avenues connected with marine structures. The most original application would be the underwater sheathing of punts and lighters. Supplies of the timber are available in great quantities in New South Wales, Australia.

PILE PRESERVATION

New Sealing Compound for Subtidal Pile Preservation

The constant occurrence of marine borer attacks located in the fault holes of turpentine piles, and the uniform attacks on other timbers below low water mark, have prompted the development of a plastic compound that can be efficiently handled in sea water, even in small quantities.

A plugging of Sealing Compound as referred to in the text. In this case the repair has been effected in a position a little above low water mark, where a fault in the pile had been attacked by "Limnoria" and a large hole excavated. When photographed the repair had been standing for approximately three years.

After many experiments with various media and quantities, a suitable mixture has been produced by R. A. Johnson, which has stood both laboratory and service tests over several years, and does not disintegrate when being applied in a proper manner under water. In the latter respect most of the difficulties of ensuring the setting of ordinary (water mixed) concrete have been eliminated, but sufficient of its hardening property retained.

The slow hardening process develops to a stage when the material will support not only its own weight, but also the superimposed weight of marine growths. Also there is an absence of cracks and shrinkage.

Following are some of the purposes for which the new plastic compound can be used:—

Plugging small holes which provide access for marine borers, particularly crustaceans.

Filling cavities in the regions of knot and fault holes which have been excavated by crustaceans.

Destruction of Timber by Marine Organisms—continued

Casing piling splices, and *for full length casing from low water mark to mud line.*

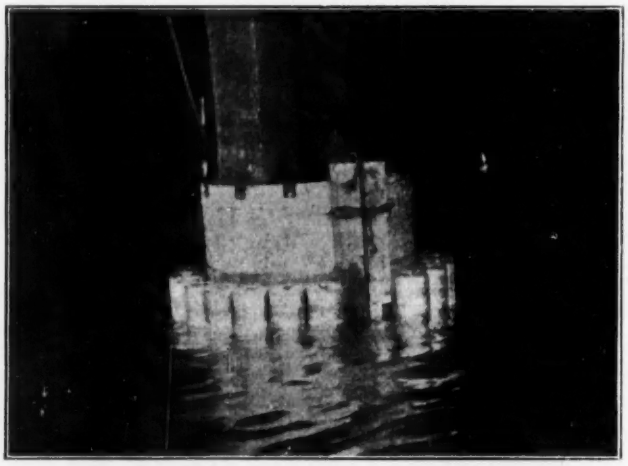
The mixture is composed of tar (crude), cement and sand in the following proportions and conditions:—

One (1) part crude tar at 72°. Fahr.
Two (2) parts cement.
Four (4) parts medium sand (perfectly dry).

The tar not only acts as a coating and binder for the solids in the mixture, but provides a medium which even in normal circumstances is resistant to marine borer attack.

Complete casing of piles can be carried out without the aid of a diver, and data show that the working cost is approximately five shillings per lineal foot. A reduction of the cost is possible if the available amount of work warrants the introduction of machine mixing, and if a suitable cheaper material than that indicated below is used for the outer temporary casing. Compared with the cost of filling several small fault holes in circumstances where the services of a diver are required, it becomes almost as cheap to employ the new compound for encasing the whole of a short length of a pile below low water mark.

Another method of casing piles with pre-cast concrete sleeves filled with sand, though effective, is expensive in comparison with the plastic compound method. In several Queensland ports this method of protection has cost between seventeen and eighteen shillings per lineal foot.



One of several patterns of the Floating Collar, devised for inter-tidal preservation. Tubular floats are arranged to permit ease of removal for repair or replacement. The unit illustrated is one of large diameter, designed to include a vertical fender on a "face" pile.

The pile shield or casing used, when applying the new compound, may be of galvanised iron or other substitute "forming" material, used as an outer casing. After fitting this around the pile, an annular space of approximately one inch is left for filling with the mixture, which packs or consolidates as it is fed from the top. If the outer casing is made of galvanised iron, it may be conveniently handled in three-foot interlocking lengths, vertically wire hinged, and fastened with slides of the same material. In cases where it is not required to encase a pile right to the mud line, the lower end of the cylindrical metal forming is sealed by bending it inwards towards the pile after shallow cuts have been made around the edge.

In some localities the galvanised iron "forming" will last for many years before completely corroding, but whatever its life in sea water, it always leaves behind the relatively indestructible compound round the pile. Abrasion is not a factor to be reckoned with, as this could not normally occur below low water mark. It is the risk of damage by abrasion which tends to confine the use of the compound for complete casing of piles to the section below low water mark, and therefore rarely makes it suitable for casing the inter-tidal zones of piles This area of major attack in Port Jackson (Port of Sydney) is well protected by the use of the cheaper, modern Floating Collar Method employing creosote. An earlier and now almost discarded method was the inter-tidal casing of piles with concrete, as described in the initial report (1932).

The Floating Collar Process for Wharf Pile Preservation.

The floating collar process was originated and developed by one of the authors (R. A. Johnson, Supervising Engineer Research, Maritime Services Board of N.S. Wales) in conjunction with the local marine borer investigations. The first mention occurs on page 145 of "Destruction of Timber by Marine Boring Or-Organisms in the Port of Sydney, 1932" (initial report). Some later details appeared on page 69 of another work similarly titled, in which the present authors were also collaborators. It covered the Port of Brisbane, Queensland, and was published as "Bulletin No. 12 of the Queensland Forest Service, 1936."

Details of the sub-tidal preservation work carried out on turpentine piles infested with "Martesia" in Bantry Bay, Middle Harbour. A: Finished top of work, projecting a few inches above low water mark. The outer casing or forming of light galvanised iron finishes level with the top of the enclosed 1-in. thick casing of Sealing Compound. B: Detail of the method of slide fastening used in securing the halved outer light iron casing.

Expansion of the treatment method in recent years embraces the preservation of some 40,000 piles in Port Jackson (Port of Sydney) at an approximate cost of ten pence per mile per annum for labour and material.. As a consequence, a new and perhaps unique organisation has developed, and field results promise well for the future. Through the successful preservation of that portion of a pile in the inter-tidal zone, it is now claimed that turpentine piling (faulty timber excepted) can be given an indefinite life in Port Jackson. The period of immunity from attack increases with each treatment, until, after the third, as much as eighteen months can elapse without further borer destruction being evident.

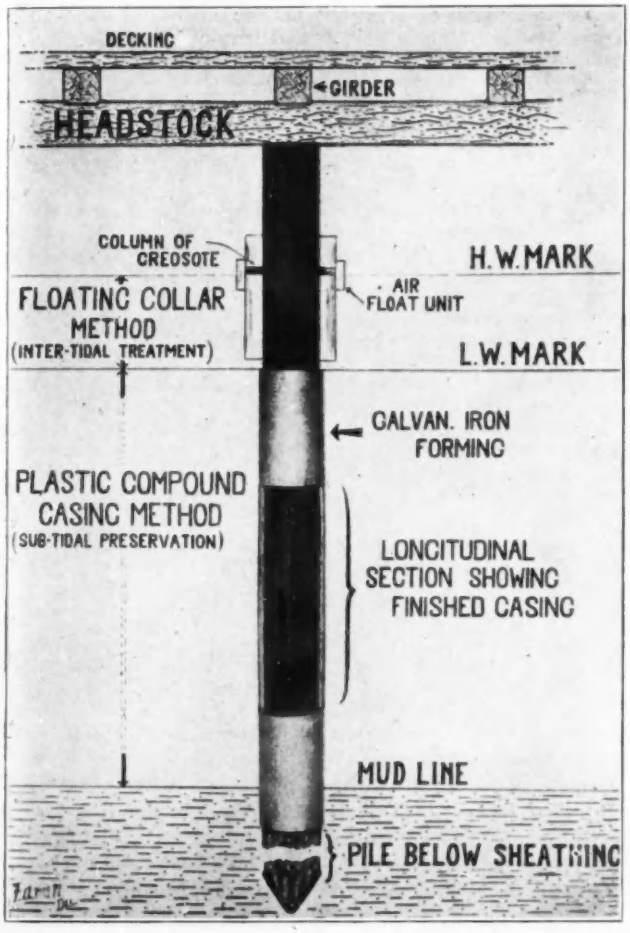
A regular treatment programme in the Port ensures closer detailed inspection of piling, a task normally carried out by special officers. An initial treatment of a pile poisons all attached marine animal and plant growth which soon becomes detached and lays bare the surface of the timber. Thus faults are disclosed which, in some cases, might have remained hidden for years, and become potential sources of trouble and expense.

As evidence of the value of ensuring the adherence of the bark on piling, the treatment of piles with original bark intact ensures that the creosote used in treatment remains for a maximum period, and will give the protecting bark layer an indefinite period of life free from crustacean borer attack. An example of this is seen in a test group of about thirty turpentine piles driven some four

Destruction of Timber by Marine Organisms—continued

years ago during alterations to a wharf at the entrance to the Darling Harbour section of the Port (Berth 1B). These had the bark covering as intact as circumstances allowed during driving, and received immediate floating collar treatment. Two further treatments followed at intervals of twelve and fifteen months and, at the end of the four years period of immersion, no signs of crustacean borer attack could be found. As proved by control observations carried out at Goat Island, near the locality just mentioned, three to four years would have sufficed for complete destruction of the bark by the crustaceans *Sphaeroma* and *Limnoria*.

The total number of piles mentioned above (40,000) are those bearing the wharves and jetties owned by the Maritime Services Board, which is a corporate government administration. Organi-

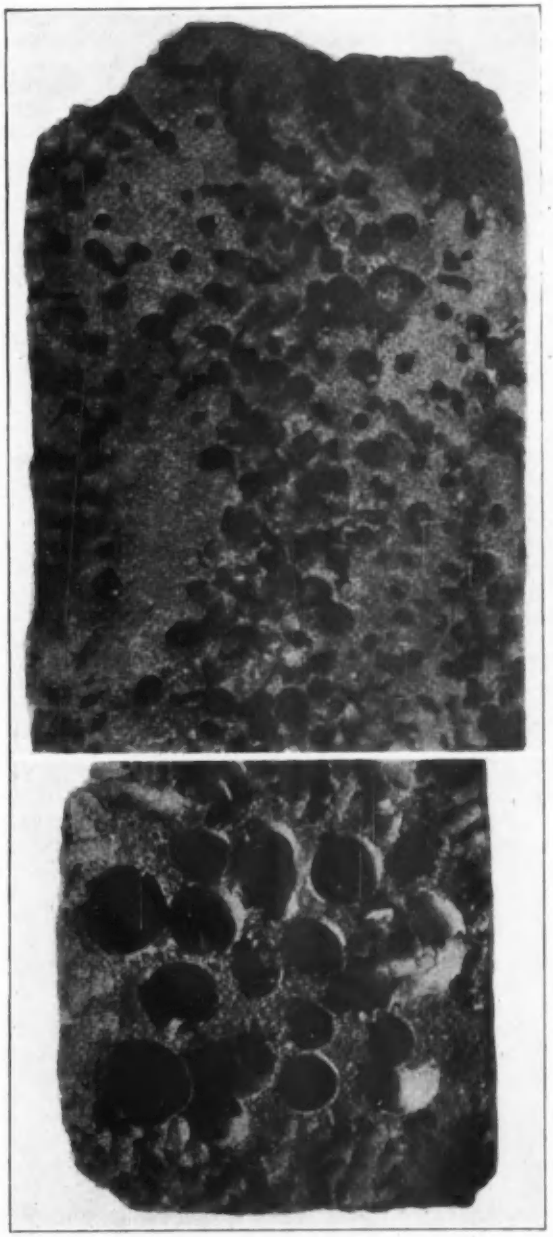


In this graphic illustration an attempt has been made to show in correct proportion the working plan of the two methods of wharf pile preservation developed for use in the Port of Sydney, from the designs of R. A. Johnson. For full description, see preceding text.

sation for the preservation treatment of the piles involved the use of eighty floating collars at the end of 1939. Only three operators are employed in manipulating the plant. This process includes transference from one pile to another every twenty-four hours, the measuring and pouring of creosote, retrieving of residue creosote and minor field repairs.

Detailed Explanation.—The floating collar process consists of the application of a surface coating of creosote to piles *in situ*, and is an advance on the method referred to earlier of providing casings of concrete, placed in position to protect the area within the tidal range, and extensively used in the Port as an initial measure of protection following the commencement of local research. The advantages are low cost, flexibility of application, and absence of added weight to a pile. A greatly extended period of useful life is assured, with facilities for constant inspection and further expansion of preservative measures in cases where required.

The process provides for the keeping of piles free from marine borer attack. It is especially suitable for wharfage areas where the timber is immune from the major forms of *Cobra* (i.e., Teredinine) attack, but is subject to the ravages of the crustacean borers. These latter have been found to operate in a dangerous manner only a short distance below the limit of the tide.



Views of a portion of an oregon fir control test sample from upper river reaches. The surface attack is entirely the work of the pill-bug, "Sphæroma terebrans." Internal destruction as disclosed by the cross section is caused exclusively by the "Cobra" form, "Nausitora."

The design of apparatus, suitable for applying the process, presented many difficulties, but a most satisfactory stage of operation has now been reached. Small improvements are being added from time to time.

Following is a description of the Floating Collar Process at present used.

Destruction of Timber by Marine Organisms—continued

The Floating Collar comprises a cylindrical, hinged, galvanised iron casing supported by floats. Placed about a pile, it leaves a freeboard of about eighteen inches to counteract wave action. The length of a cylinder may be as much as desired up to a maximum of, say, eight feet; the longer lengths provide for additional depth of pile surface covered below low water mark. The diameter of the iron casing is determined so as to leave a small annular space between its inner surface and the pile it surrounds. The space is sufficient to enable any residue of creosote, that may be left after treatment, to be removed. Various designs have been experimented with and it has been found that two types are successful in service: (1) a unit constructed with heavy gauge iron carrying fixed floats and welded throughout; (2) a structure of light or medium gauge galvanised iron containing detachable floats which can be readily serviced. A third design constructed of timber is still in the experimental stage.

Any toxic, relatively non-soluble liquid with a suitable specific gravity below 1.00 can be used. The liquid is poured on the water to cover the area between the casing and the pile. A ring of the poison thus floats on the surface, and the gradually displaced water below is forced through the open bottom of the cylinder. No toxic liquid escapes at any time from the bottom of the cylinder, since a definite balance preserved between the specific gravity of the liquid and the sea water ensures its safe retention.

A great deal depends upon the time during which the toxic liquid makes contact with the surface of a pile. A gallon of suitable creosote, for instance, gives a column over one inch deep when there is an annular space of about three inches between pile and collar. This would be in contact with every portion of the timber surface for a minimum period of about six minutes during every journey up and down on a 5-ft. tide. At both high and low water the period of contact is increased to a maximum of about eighty minutes. At the lower points especially, the increased time of contact for impregnation is most beneficial, for it is there that the greatest intensity of attack is encountered.

Unabsorbed creosote, remaining on the surface of a pile, and dislodged after the floating collar has moved upwards with the tide, rises to the surface within the collar, and minimises loss of the treatment liquid. On the other hand, as the tide recedes the creosote not absorbed by the upper timber surface flows downward and increases the time of contact. After a reference to the tidal graphs of Port Jackson (Port of Sydney), and the **making of allowances for the additional time of contact,** as just described, it has been determined that for tides of a 5-ft. range over twenty-four hours, a column of oil one inch deep within a floating collar would have direct contact with a pile surface for about one and a quarter hours at a point midway between high and low water marks, and about two and a half hours at high water, and a similar period at low water.

When occasions arise for the treatment of an area on a pile below low water mark, the addition of extra creosote will bring about an increase in the depth and cover of that fluid. The process of increasing the depth of treatment is a flexible one, limited only by the depth of the floating collar employed. In such instances the residue is much more bulky than in normal circumstances, and its recovery invites the use of some simple pumping device.

It has been found that twenty-four hours floating collar treatment of a pile, covering two falling and two rising tides, will kill all crustacean borers. Similar annual applications are considered necessary only in the first few years of treatment. After this, periods between treatments may be lengthened, these being determined by the circumstances of individual cases.

SUPPLEMENTS

Summary of Matter in "Destruction of Timber by Marine Organisms in the Port of Sydney, 1932"*

The study of marine borers and their depredations was placed on a systematic basis for the first time in Australasia.

Results from experiments carried out over a period of three years at thirty-seven testing stations were presented, with the incidence of marine borer attacks at each carefully recorded and published in tabulated form.

Specially prepared graphs of attacks intensities and water conditions were prepared for each testing station in order to assist the reader in interpreting the data collected

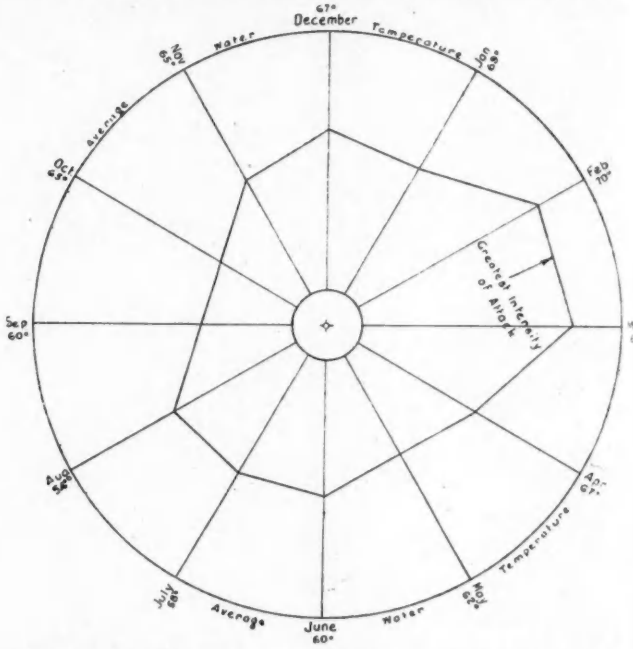
A systematic account of the *Cobra* borers and an article on their crustacean associates appeared, both fully illustrated.

Attacks by *Cobra* borers were proved to be carried out by many different species, all of which were hitherto undescribed.

Certain localities in the Port were found to be decidedly less affected than others by the depredations of marine borers, and thus was opened up a further interesting field of enquiry in the determination of governing factors responsible for these differences.

Specific differences of attack for the inter-tidal zone and the area below low water mark were determined, and data gathered for the execution of practical measures of preservation.

Station No. 31 The Spit Middle Harbour showing Annual Peak of Destruction by borers, 1932-33-34. Attack by "Cobra" borers only.



Average salinity, 29 grammes per kilo. Average hydrogen ion concentration, 8.25. Average oxygen, 5.50 c.c. per litre.

A way was shown for the effective treatment of damaged piles by the use of direct cement casings, which were employed as an initial step in preservation methods, as opposed to costly replacements.

Attention was drawn to various modes of attack, and in this regard the must vulnerable points of entry into timber were indicated.

The paramount importance of turpentine as a piling timber in the Port of Sydney was verified, and emphasis laid on the necessity for retaining its bark in an undamaged state as a protection against borer attacks.

Comparisons were drawn between conditions of marine borers in Sydney and Brisbane waters, a procedure not previously attempted for any two Australian ports.

A most complete review of marine growth likely to be found on piles was prepared, and a table drawn up to show occurrences at various seasons of the year.

II.—Summary of Matter in "Destruction of Timber by Marine Organisms in the Port of Sydney; Supplementary Report, No. 1, 1936."

The study of the depredations of marine boring pests in the Port of Sydney was advanced another stage with the inauguration

*Referred to in this supplement as the initial report.

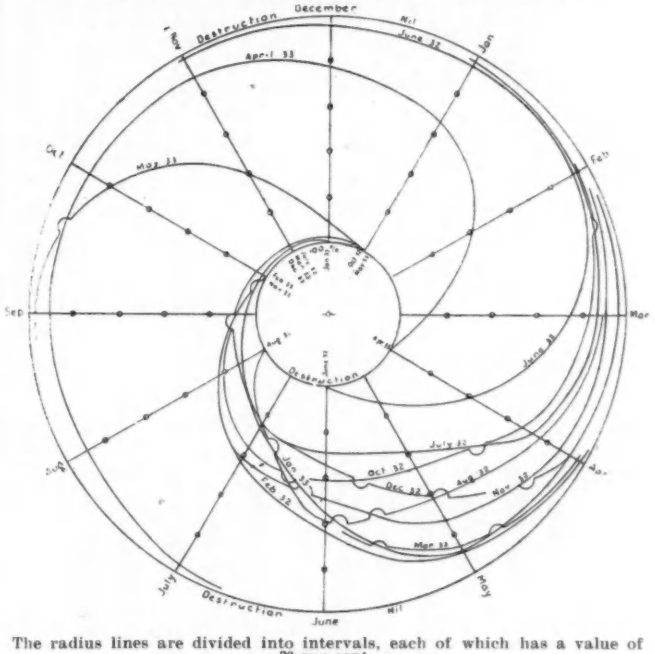
Destruction of Timber by Marine Organisms—continued

of a series of Control Test Stations for the determination of Annual Cycles of Attack. With those results some very definite and reliable evidence was made available, defining the seasonal periods of the year when the pests are most destructive, and thus indicating the times when the employment of preventive measures is most effective and economical.

Full records from two station sites at opposite ends of the Port were presented. Coupled with the compact graph illustrations, a very striking contrast of attacks was recorded.

The investigation work established that the virile *Cobra* form *Nausitora* is confined to the low salinity waters of the upper river and harbour reaches of the Port. Thus it does not *at present* constitute a menace as was suspected on the evidence suggested by the previously unique specimen collected by Chas. Hedley, and bearing the general locality "Port Jackson" (Port of Sydney).

Station No. 31 The Spit Middle Harbour. Progress of destruction of 12 Oregon samples set at monthly intervals and used for determination of annual cycle of attack. Attack by "Cobra" borers only.



The radius lines are divided into intervals, each of which has a value of 20 per cent.

Average salinity, 29 grammes per kilo. Average hydrogen ion concentration, 8.25. Average oxygen, 5.50 c.c. per litre.

Through the institution of Annual Cycle of Attack tests evidence relating to the fluctuations of *Cobra* larvæ provided the reason for changed progress of attacks.

It was established after intensive observations that the sapwood of turpentine piles does not register within measure the resistance proved for the truewood of the same timber; this has a special significance in cases where sawn material is used in any part of submerged marine structures.

Following the identification of Nereid worms as scavengers, some thread-like worms and leaf-shaped Planarian worms have been similarly recognised. No direct evidence was obtainable, however, to prove that the scavengers in question are responsible for any mortality among *Cobra* borers.

As a result of the close inspection of the control test samples of oregon fir in the series of experiments reviewed, it was established that *Cobra* borers survive for approximately six months after reaching a stage when no further possible nutriment could be obtained from the timber.

Claims made respecting the partial sustenance of *Cobra* from the timber fibre consumed were strengthened by the series of observations recorded.

The more critical methods and inspection of control test samples adopted, have enabled the determination of a record time (two months, exclusive of the initiation period of attack), for the destruction of standard test samples of timber by *Cobra* in the Port of Sydney, and possibly for the world.

Further evidence was advanced concerning the marked destruction by *Sphaeroma* in the Port.

Chelura, invariably an associate of *Limnoria* in softwood, was considered not to be a factor in the destruction of the hardwoods used in wharf construction.

As already established for numerous marine creatures in temperate and tropic seas, *Cobra* in the Port of Sydney was observed to breed throughout the year, but new evidence was recorded of one intensive breeding season during the warmest months of the year.

Notwithstanding the amount of additional data concerning marine growths in association with borer-attacked timber, a definite value could not be claimed for them as reliable palliatives.

III.—Brief Outline of the Scope and Results of the Present Report.

Completion of research respecting the Annual Cycle of Attack observations at four selected control test stations in the Port of Sydney.

Detailed records of the balance of two stations of the original four, as above, are presented. The evidence of borer attacks, given in both the test and graph illustrations, though different in character, discloses a less striking contrast than was the case with the two control test stations initially studied and recorded (see Supplementary Report, No. 1, 1936).

Close comparison of the activities of the crustacean borer *Limnoria*, embracing three adjacent test station sites in the Port, shows the vagaries of distribution and attack which make it impossible to accept evidence from one locality as applying to the Port as a whole,

As the result of experiments and field observations, it has been established to the authors' satisfaction that *Chelura*, the associate of the destructive borer *Limnoria*, has no significance as a boring organism.

The efficacy of marine growths as aids in the prevention of *Cobra* borer destruction was proved by a critical series of tests.

The reaction of turpentine piles to sub-tidal attacks by *Limnoria* is discussed in connection with damage done to the piling of several jetties in Walsh Bay, Port Jackson.

An initial record of serious damage by the pholad mollusc *Martesia* is described and details given of the methods employed to combat this new menace to piling in Port Jackson (Port of Sydney)

A full description is given of the Floating Collar Method for inter-tidal treatment of piling; and also details of the recently developed Plastic Compound Casing Process for sub-tidal preservation of piling.

More evidence is provided respecting partial and full life spans of *Cobra* borers.

An endeavour has been made to present from results comparisons between the *Cobra* borer attacks of the four test stations specially selected for the Annual Cycle of Attack observations.

Information has been secured, through experiment, respecting the effects of fresh water on *Cobra* borers other than *Nausitora*. The data should have a wide practical scope of application.

Note: The diagrams shown above in the Supplements are referred to on page 83 of the August issue, from which they were unfortunately omitted.

Government Canal Control.

Exercising powers conferred on him by Regulation 69 of the Defence (General) Regulations, 1939, the Minister of War Transport has made an Order in which he takes control of eight undertakings, or portions of undertakings, in Great Britain, owned by, leased to or operated by the following undertakers: (1) The Anderton Company, Ltd., (2) Direct Delivery Service, Ltd., (3) Furley and Company, Ltd., (4) John Runt and Sons (Leeds), Ltd., (5) The Mersey Weaver and Ship Canal Carrying Company, Ltd., (6) H. Oldridge and Son, (7) Ernest Thomas and (8) Trent Carriers, Ltd. The Order came into force on August 1st last.

Port Planning and Terminal Design in Relation to Economical Cargo Handling

By H. E. STOCKER,
Assistant Professor of Transportation, New York University, and
Director of Harry E. Stocker Associates.

Scope of Paper

THIS paper considers port planning and terminal design in relation to cargo handling with particular reference to problems studied by the writer in the Port of Honolulu during 1940 for the Matson Navigation Co., supplemented by data from reports to other clients on terminal problems elsewhere.

The chief objectives in the Honolulu survey were to determine what should be done to relieve congestion on the terminals, to determine the location of a new Territorial terminal, if one was necessary, and to plan details of its design in so far as they were related to economical cargo handling and prompt dispatch of ships.

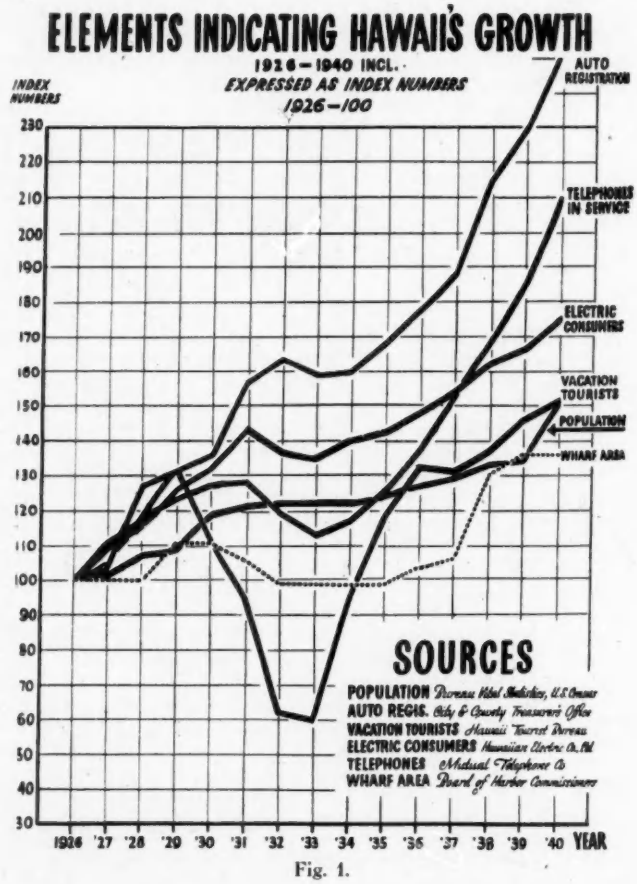

ELEMENTS INDICATING HAWAII'S GROWTH
1916–1940 INCL.
EXPRESSED AS INDEX NUMBERS
1926–100
INDEX NUMBERS
AUTO REGISTRATION
TELEPHONES IN SERVICE
ELECTRIC CONSUMERS
VACATION TOURISTS
POPULATION
WHARF AREA
SOURCES
POPULATION Bureau Hotel Statistics, U.S. Census
AUTO REGIS. City & County Treasurer's Office
VACATION TOURISTS Hawaii Tourist Bureau
ELECTRIC CONSUMERS Hawaiian Electric Co. Ltd
TELEPHONES Mutual Telephone Co
WHARF AREA Board of Harbor Commissioners
'26 '27 '28 '29 '30 '31 '32 '33 '34 '35 '36 '37 '38 '39 '40 YEAR

Fig. 1.

It is hoped that reporting the more important parts of these studies will be helpful to those making similar studies in other ports.

Port Planning at Honolulu.

Berthing facilities were not found to be as much of a problem as space for cargo discharged from ships. The number of berths available has been increased by putting more ships into Pearl Harbour than in the past.

*Paper read at the Annual Convention of the American Association of Port Authorities held at Miami, Florida, in November, 1941.

The congestion in Honolulu, which was proving costly primarily because of delays to ships, was due to the large increase in traffic resulting from heavy national defence tonnage, superimposed on an increase due to normal economic growth. For example, in the first eight months of 1940, inbound traffic increased 50% as compared with 1939.

The standard of living in the Islands had been increasing and with that had come additional traffic from the mainland. The accompanying graph (Fig. 1) is interesting in this regard, showing as it does a much more rapid increase of automobile registrations, building permits, and telephone installations, than of population.

Relation of Cargo Movement to Wharf Area

Statistics on cargo moving through the port are available only since 1929. In the following table and accompanying graph (Fig. 2) the writer shows the volume of overseas cargo moving into the ports in each year, the area of Territorial and privately-owned wharf space available and the ratio of cargo movement to total wharf space.

There has been considerable laxity in recording tonnage and area figures over the years. The following table may not be entirely accurate, but the figures are satisfactory for all practical purposes:—

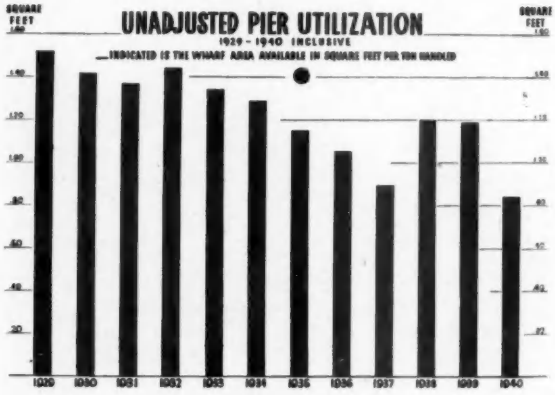


Fig. 2.

Table Showing Area Available per Ton of Cargo Handled

Year		Inbound Tonnage	Territorial Space	Shedded Wharf Area, in sq. ft., Private	1,129,679 Total	Square feet Available per ton Handled
1929	...	607,780	705,174	213,235	918,409	1.51
1930	...	652,465	705,174	213,235	918,409	1.41
1931	...	646,877	670,944	213,235	884,179	1.37
1932	...	571,684	607,944	213,235	821,179	1.44
1933	...	612,528	607,944	213,235	821,179	1.34
1934	...	636,330	607,944	213,235	821,179	1.29
1935	...	711,127	607,944	213,235	821,179	1.15
1936	...	816,409	607,944	250,135	858,079	1.05
1937	...	994,260	607,944	276,135	884,079	.89
1938	...	901,944	607,944	476,135	1,084,079	1.20
1939	...	951,922	607,944	521,735	1,129,679	1.19
1940	...	1,344,782	607,944	521,735	1,129,679	.84

For the years shown, the two years of peak congestion were 1937 and 1940. The 1940 tonnage figures include substantial shipments for defence purposes and they are therefore abnormal.

Much of the cargo passing through the port in 1937 would have been handled in 1936, but for a protracted shipping strike. When the strike ended, the port was congested for months. Normal cargo movements were heavy for the remainder of the year.

Port Planning and Terminal Design—continued

Private terminal interests, sensing the traffic trend and realising that the legislature was not going to appropriate money for new piers, constructed 245,000 sq. ft. of additional facilities during the following four years.

The figures for total square feet available in the port do not distinguish between terminal facilities which are usable but which are economically obsolete, and those which are not obsolete. Pier 7 (owned by the Territory) whose area is included in the figures, is short and narrow and it has been little used since 1937, except under pressure of congestion.

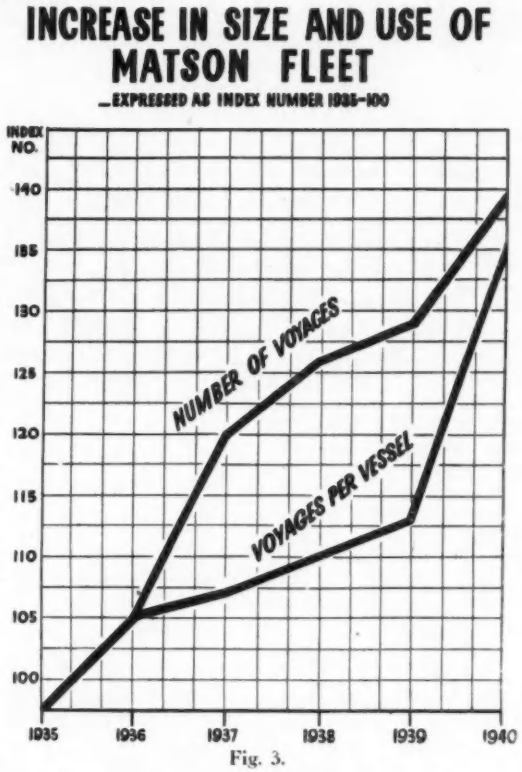


Fig. 3.

Pier 15 is also inadequate for modern ships and cargoes, which fact has restricted its usefulness.

Relationship of Idle Ship Days to Working Days.

The following table and accompanying chart (Fig. 4) show for each year since 1934 the percentage of idle ship days due to congestion out of the total working days in the port for each year since 1934:—

Year	Percentage of Idle Days to Working Days
1934	4.50
1935	4.69
1936	10.13
1937	12.51
1938	14.95
1939	15.65
1940	16.96

How Congestion was Reduced

To correct these conditions, which were destructive to economical ship operations, the first consideration was to determine what could be done to reduce terminal congestion without any expenditure for modification of the existing terminals or for the construction of new terminals.

Congestion had been relieved to some extent by greater utilisation of open areas near some of the piers.

The movement of cement in bulk rather than in bags, has relieved terminal congestion at Honolulu, although that was not the purpose of the new method.

Since the writer made his survey in Honolulu, some of the sugar interests have started construction of terminal storage tanks in preparation for handling of raw sugar in bulk. Similar installations are planned at the Hawaiian Ports of Hilo, Port Allen, and Kahului.

This new method, however, will have little effect on terminal congestion at Honolulu, as far as pier space is concerned, for only a little sugar is handled on the decks of general cargo terminals. Most of it moves overhead by means of conveyors across the terminal from warehouse to the ships. Warehouse space adjoining some piers may, however, be made available for other cargoes when sugar is handled in bulk, and thus relieve the congestion on piers.

The problem of congestion in Honolulu was also solved in part by using the modern cargo handling equipment available on the terminals of the Castle and Cooke Terminal Co., who do most of the stevedoring in the port, to pile cargo higher than previously.

In terminal use, as in the use of ship, airplane, railroad, car or factory, a very important consideration affecting economy is the load factor, or extent to which practicable capacity is being utilised. By use of fork trucks and pallets many terminals at various ports now pile cargo to great heights economically, thereby increasing the load factor. Some steamship lines could not handle the cargo they do on their terminals, but for the use of this equipment. Cases, barrels, and bags of commodities, are piled four and five pallets high, thereby utilising air space in a pier shed which before was either wasted or used only by expensive piling methods.

The Castle and Cooke organisation has provided large quantities of this new modern equipment, so that the most effective use would be made of terminal space available.

The writer's organisation was also asked for suggestions, and in the course of the past year sent reports on steps taken by other stevedores to relieve congestion.

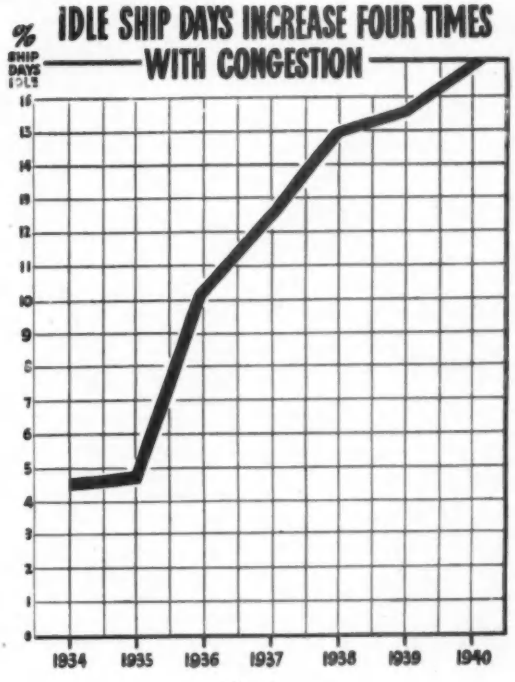


Fig. 4.

Modern Motor Transportation has Created New Terminal Problems

The congestion at Honolulu, due to increased tonnage, was aggravated, as it has been elsewhere, by motor trucks receiving and delivering cargo, particularly those of large size which require so much space in which to turn round. (See Fig. 5).

Modern motor truck transportation has created new problems for the terminal operator, but there has been little progress in terminal design to take care of these problems.

Port Planning and Terminal Design—continued

Many terminals now in existence were either built before the advent of motor transportation, or their design incorporates no changes to take care of the problems created by this new method of transportation.

The writer, however, before giving consideration to problems of terminal design at Honolulu, gave consideration to the means by which truck traffic could be reorganised so that expenditures for modification of existing terminals or for construction of new ones would be minimised. He concurred in recommendation of another organisation as to a means of controlling truck traffic by inaugurating store door delivery service, provided a detailed study justified the conclusions based upon the initial survey.

The more trucks operating under control of the terminal organisation, the less difficulty there would be with trucks loading cargo.

Although no action has been taken with respect to this recommendation, progress has been made in relieving some of the congestion by having truckmen provide adequate equipment to move the cargo quickly, thereby releasing terminal space for other cargo.

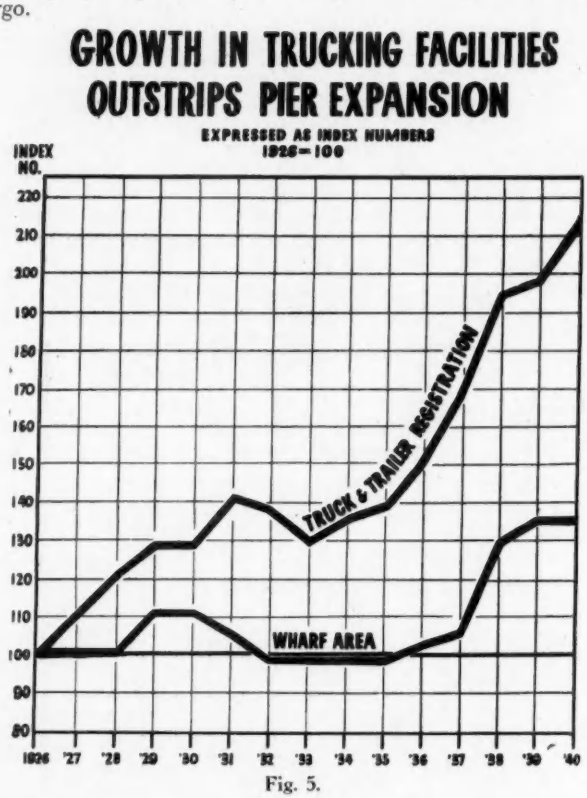


Fig. 5.

Elsewhere, a steamship line has improved conditions with respect to handling of truck traffic by insisting upon loading trucks rather than allowing the public loaders to do this work. It has been their experience that the work proceeds more efficiently; trucks are loaded faster, and hence congestion is decreased.

At New York the problem of truck traffic will be improved in part by a new service soon to be offered by a trucking company. Shippers' trucks will deliver small lots of export cargo to a terminal or consolidation point. The trucking company will then make up solid truck loads for each export pier.

The advantage to the steamship lines is the reduction of complaints from shippers and reduced congestion on their piers, because less trucks will be handled for a given amount of cargo.

It is highly desirable to keep motor trucks, as well as railroad cars, out of a congested pier if it is practicable to do so.

When modern cargo handling equipment is available on a terminal it is more economical to haul cargo comparatively long distances than to congest the terminal with transportation equipment.

Facilities for Receiving Cargo

The provisions for receiving cargo on the wharf at the head of slips (known in New York as bulkhead-receiving) has proved to be an effective means of expediting trucks and relieving congestion.

In many cases most of the truck loads were small and it is possible to keep them off the piers without any great difficulty. One steamship company in New York found that 75 per cent. of the trucks handled only 25 per cent. of the cargo. Receiving on wharf at head of slip kept practically all of the 75 per cent. off the narrow congested pier.

In a recent week, at one terminal, 1,491 trucks delivered 1,469 tons at the bulkhead platform, while only 297 trucks were taken down the pier. The latter delivered 2,485 tons.

Several years ago, when this company started to handle trucks at the bulkhead platform rather than on the pier, the whole plan was strenuously opposed by the man in charge. Now, however, the superintendent is so enthusiastic about this method that he would like to have all trucks received at the bulkhead platform, regardless of size of load.

Receiving cargo at bulkhead is economical only when mechanical equipment of proper design is available to move the cargo to the ship or to a designated place on the pier. Tractors and trailers are generally used to do this work. The work is done most economically where the cargo is first placed on pallets and these are in turn placed upon trailers for the long haul down the pier.

With fork tracks and pallets available, a raised platform for handling trucks is not as necessary as formerly.

One line receives and delivers all truck cargo on the street outside the shed. It is handled from the trucks to the two elevators at the street end of the pier almost entirely by fork trucks and pallets. At or near that point the loaded pallets are placed on trailers.

After delivery on to the upper deck by elevators, the trailers are made up into trains and hauled to the proper place on the pier, where the pallets are removed by fork trucks and pile four or five high.

Pier congestion has been reduced and some of the space formerly occupied by motor trucks is available for cargo. The stevedore has found that the absence of motor trucks on the terminal has been highly advantageous.

(To be continued)

Galway Harbour Development

Completion of Works Programme.

The following particulars of works recently carried out at the Port of Galway, Eire, have been furnished by Mr. W. N. Binns, B.E., the harbour engineer.

The contract for the Galway Harbour Development Scheme, amounting to £200,000, was completed by the Associated Contractors, Ireland, on 24th June, 1942.

The works comprised the lengthening and deepening of the Dun Aengus Dock, allowing vessels up to 350-ft. in length to enter; the widening of the entrance from 54-ft. to 65-ft. and the provision of new gates; and the building of an extension pier at the entrance, 350-ft. long and 65-ft. wide, with a deep water laybye on the Eastern side. The original intention to erect a transit shed on the pier has been postponed on account of war-time difficulties.

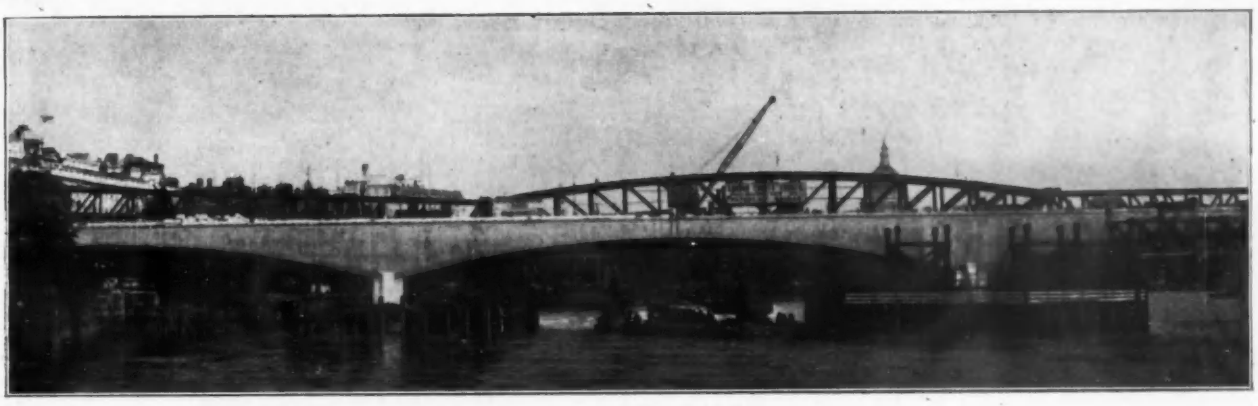
There has also been carried out the removal of a rock barrier outside the entrance, and the dredging of a sand bar about 800 yds. long by 260-ft. wide, so as to give access to and from deep water. The dock will now admit of the reception of vessels drawing 25-ft. at spring tides, and 20-ft. at neaps. The Old, or Commercial, Dock has an entrance 54-ft. wide and can only admit vessels drawing up to 16-ft. at spring tides.

A depth of 12-ft. of water at low spring tides is provided throughout in the Dun Aengus Dock. This allows a passenger tender to leave Galway Harbour at all stages of the tide to reach steamship liners in the Bay which discharge at Galway about 2 miles from the dock. The laybye provides sheltered accommodation for the berthing of tenders, for fishing boats, yachts, etc.

The New Waterloo Bridge

Reinstatement of Highway across the Thames

The transfer of vehicular traffic to the new Waterloo Bridge on August 11th marked an important stage in the completion of this great work in the port area of London, which was begun in October, 1937, and has proceeded despite war-time difficulties. But for the war the bridge would probably have been completed during 1940.



The New Waterloo Bridge under Construction.

Following the failure of the first Waterloo Bridge, which was designed by Rennie and completed in 1812, Lord Ritchie, in 1934, on behalf of the Port of London Authority (of which he was then chairman), with the support of riverside interests, expressed grave doubts whether the proposals for reconditioning the old bridge were adequate for safe navigation of the river during the execution of the work and made representations for the adoption of a suspension bridge, or failing that, for any form of bridge with not more than five arches.

The new bridge has five spans of about 240-ft., in place of nine 120-ft. arches in the old bridge, and is designed as a continuous beam with a suspended portion in the middle span. The navigable channel is covered by two of the spans and their great width will benefit navigation in this awkward reach of the river, while the slender design of the superstructure provides improved headroom and will afford river traffic a clearer view through the bridge, particularly when the adjoining temporary bridge is removed in due course.

The new bridge will accommodate six lines of vehicular traffic as compared with three lines on the old bridge, but it will not be fully in commission until certain subsidiary works are completed, probably early next year.

The design is modern in character and the main effect is seen in its general lines and proportions. An unusual effect results from the employment of twin main members with a flat soffit between them. The northern span springs from the inner side of the Victoria Embankment and the first pier is well out into the river. The construction is of reinforced concrete with a facing of Portland stone, except at the piers which are faced below high-water level with granite from the old bridge.

The design of the bridge is the result of collaboration between the London County Council's appointed engineers, Messrs. Rendel, Palmer and Tritton, and the appointed architect, Sir Giles Gilbert Scott, R.A., in association with the Council's Chief Engineer, Sir Peirson Frank, M.Inst.C.E., F.S.I. The contractors are Messrs. Peter Lind and Co., Ltd.

The Shipping Diversion Committee

The diversion of ships from one port of destination to another in consequence of circumstances arising out of the war is controlled by a special committee composed of representatives of the Admiralty, War Office, Air Ministry, United States Army, H.M. Customs and Excise, Dock Labour Corporation, Ministry of Supply, Ministry of Food and Ministry of War Transport, together with port officers representing various areas. The chairman is Mr. W. Donald, C.B.E., the deputy chairman, Mr. G. P. Graham and the Secretary, Mr. D. P. Sinnott.

The following description of the current work of the Committee is extracted from an article by a Special Correspondent in a recent issue of *Lloyd's List*:—

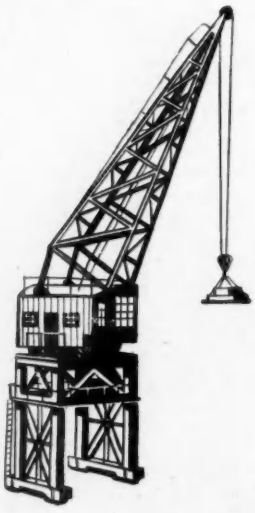
The port representatives are all experts in their own area and they are in direct telephonic contact from the committee room with their ports. At any time they are able to give the position at their ports, what berths are occupied and which are free, not only at the moment, but in 10 days' or a fortnight's time. The committee has full executive authority, and the decisions taken at the daily conference are final and binding.

When a ship is loading, and before she leaves her oversea port in convoy, she is provisionally allocated to a certain British port. After she has sailed, and with full knowledge of every type and weight of cargo she carries, it is the work of the Shipping Diversion Committee to consider if the provisional port shall be the final port, or whether, in the light of changed conditions in the port or the country, or the requirements of the consumers, the vessel shall be diverted to another port better suited for the distribution of the cargo. One of the most important considerations for the committee is the ability of a port to turn the ship round quickly. They must know if the port is capable of taking the ship, whether there is a suitable berth available, and whether the port is suitable for the cargo to be readily distributed over the available transportation systems. Congestion must be avoided—an important point when large convoys arrive—for if the port is congested the next convoy will be held up. The question of labour must be considered, together with the suitability or otherwise of the handling appliances at the port. The work of the committee can, in fact, be summed up in few words—to get the utmost use out of every ship while, at the same time, throwing only the minimum of strain on our inland transport.

Each representative has before him a list of expected ship arrivals. This list contains such details as the name of the vessel, owner, flag, tonnage, draught, where from, details of cargo and provisional port of discharge. In the case of a single bulk cargo such as oil or wheat, the provisional port is usually, though not always, the final port. It is the vessels carrying mixed cargoes that constitute a problem, for while one particular port may be admirably situated for the ultimate destination of part of the cargo, that port may be of little use, for various reasons, for enabling the rest of the cargo to reach its destination easily. Where possible, two ports of discharge are avoided, and it is only for urgent priority reasons that ships are allocated to two ports.

A typical, though hypothetical, example of diversion is that of a ship provisionally allocated to Port "A." Among the cargo is a large parcel of steel, a quantity of timber, and a small quantity of special priority cargo. Port "B" is suitable for the steel, Port "C" for the timber, and elsewhere for the priority cargo, but no one port is suitable for all three. On the other hand, Port "D" can take the vessel, discharge her quickly and get the cargo away easily to all destinations. Accordingly, the vessel is diverted to Port "D."

LOADING SHIPS This picture is as out-dated to-day as a regiment of archers. The modern war is one of mechanism and speed—tanks move faster than infantry, bombs travel farther than shells, and cranes load a ship more readily than human labour ever can. Throughout the civilised world to-day, Smith Cranes are lightening the tasks of man in wartime—as tomorrow, with equal dependability, they will lighten his tasks in peace.



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